2

Discovering Our World

CURRICULUM

TEACHERS EDITION

Ex libris
universitatis
albertaensis

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/curriculumfounda02beau

Educ
Q
163
B37
gr 5
tch.

TEACHER'S GUIDEBOOK

FOR

Discovering Our World

BOOK 2

WILBUR L. BEAUCHAMP
MARY MELROSE WILLIAMS
GLENN O. BLOUGH

SCOTT, FORESMAN AND COMPANY

CHICAGO ATLANTA DALLAS NEW YORK

Copyright, 1948, by Scott, Foresman and Company

Printed in the United States of America

LIBRARY OF [illegible] UNIVERSITY

Contents

PAGE

Preface 4

PART ONE. **Philosophy and Technique** 5

- Why Teach Science? 5
- Learning and Science Teaching 7
  - Conditions for effective learning 7
  - The teaching cycle 8
  - Organization of this series 9
- How to Use This Book 10
  - Fitting the book to local conditions 10
  - General suggestions for teaching the units 11
    - Preparing to teach 11
    - General procedures 12

PART TWO. **Suggestions for Teaching the Units** 20

- Using the Introduction 20
- UNIT 1. How Do Living Things Help and Harm Each Other? 21
- UNIT 2. What Makes Things Move? 31
- UNIT 3. How Is Our Work Made Easier? 38
- UNIT 4. How Do Heating and Cooling Change Materials? 46
- UNIT 5. What Are Things Made Of? 53
- UNIT 6. How Do We Control Fire? 59
- UNIT 7. Why Do You Need Food? 65
- UNIT 8. Where Does All the Food of the World Come From? 73
- UNIT 9. How Can You Make a Garden? 78

PART THREE. **Bibliography** 85

- Supplementary Reading for Pupils 85
- For Pupils and Teachers 86
- For the Teacher 87

PART FOUR. **Materials and Sources** 90

- Care of Living Things in the Classroom 90
- List of Materials 94
- Supply Houses 95
- Visual Aids 96

128356

Preface

The impact of science on daily life emphasizes the need for an organized science program throughout the elementary grades. A new subject not many years ago, science now occupies an increasingly important place in the curriculum. Experienced teachers have discovered that science is not mysterious. It is no more difficult to teach than other subjects long taught in the elementary school. In fact, the child's natural curiosity about the world in which he lives makes science teaching easy. Motivation is never lacking in a properly conducted science class.

Yet many teachers, untrained in science, are fearful of science teaching. They suspect (often rightly) that pupils know more about science than teachers do. And they tremble at the thought of being asked a question that they cannot answer. These teachers lack confidence because they lack training in science. The purpose of this *Guidebook*, therefore, is to provide in-service training in science teaching. It is designed to help the inexperienced teacher learn as she teaches. Although intended primarily for teachers who lack the background and experience required for effective science teaching, the *Guidebook* also provides much information that will be useful for experienced science teachers.

Part One of the *Guidebook* discusses the philosophy of education and the technique of teaching used throughout the *Discovering Our World* series. It is divided into three main sections. The first section takes up the objectives of science teaching. The second covers the conditions of effective learning, the teaching cycle, and the organization of the series. The third deals with general methods for teaching science effectively. Part Two gives specific suggestions for teaching each unit in the pupil's book. Part Three is a book list. Part Four gives information about the care of animals and plants in the classroom, materials needed for the experiments and observations, and visual aids.

The usefulness of the *Guidebook* will be apparent to teachers acquainted with the books that precede or follow *Discovering Our World* in the *Basic Studies in Science* program. The suggestions have come from years of experience of the authors, their colleagues, and the teachers who kindly helped in shaping the book. The authors will be glad to receive additional suggestions for making this *Guidebook* a more effective teaching aid.

Why Teach Science?

Instruction that does not transfer over to life, providing a guide for behavior in the situations that arise, does not function. Therefore, the task of the teacher of science or of any subject is to determine what modifications of behavior can be brought about by that subject. A boy or girl who has studied science should be a different individual from the one who has not studied science.

The problem that every teacher of science must solve is: How can I so teach science that it will function as a way of living, as a mode of interpreting the world in which we live, as a way of reacting to our environment? Science so conceived is not simply a collection of facts about the various forces, materials, and phenomena of nature; it is a method of behavior.

If we analyze the ways in which a study of science will contribute to desirable modifications of behavior, we find five ways in which modification can be brought about.

1. The first way of modifying behavior through science is *by developing a genuine interest in the world of nature and a desire to know more about it.* A prerequisite to this interest is a rich background of experiences with the forces, materials, phenomena, and living things that make up the world in which we live. In this series, the authors have provided this rich background of experiences. They have also suggested activities that the child can carry on to discover more about the world in which he lives. A person who has acquired this interest has a never-ending source of satisfaction.

2. The second way in which the study of science can modify behavior is *through an understanding of the forces, phenomena, processes, materials, and living things that interact to produce the world in which we live.* Learning is essentially a process of acquiring meanings. When a thing, situation, or event has acquired meaning, it is understood. Perhaps the best statement of this idea has been given by Dewey: "To grasp the meaning of a thing, an event, or a situation is to see it in its relations to other things, to note how it operates or functions, what consequences follow from it, what causes it, and to what uses it can be put." Thus, one problem of the science teacher is to discover how the child acquires meanings.

A major type of learning in science is the acquisition of general concepts. Such general concepts cast a flood of meaning over the forces, phenomena, and materials of the environment with which the child comes in contact. Let us take an example. To identify a thing as a member of a certain group is to explain it, or to give it meaning. If we say that a thing is a "living thing," you know in general what kind of thing it is. You know that it carries on certain processes and activities. You know all this because you have acquired a general concept of what a living thing is. By means of such concepts, you are able to generalize, to carry over meaning from one situation to another.

In the teaching of science, we need to keep in mind the development of general concepts —concepts that may transfer to other situations and serve as a method of interpretation and explanation for particular things, events, and situations.

If you have studied science, you know that science generalizations are often stated as principles. For example, "Solids expand when heated and contract when cooled" is a statement of a principle. The principle tells you what happens when a certain condition is present. If you heat a solid (the condition), it will expand (the effect). A principle, therefore, is a statement of the relation between conditions and effects.

Since these principles are general in their operation, they interpret behavior and supply a guide for it in many situations. For example, consider the idea of gravitation. A baby takes a long time to discover the force of gravity. Through experience, he finally discovers that an object will fall unless there is some support beneath it. Then he may take great delight in dropping objects just to see if what happens will meet with his expectations. Finally, he generalizes and arrives at the conclusion that all objects must be held up by something, or they will fall. He has now acquired a method of behavior that enables him to deal successfully with situations in which the force of gravity is operating.

This example shows that a principle of science is not simply a collection of words to be memorized; it is the basis for a method of behavior. A person who understands a principle behaves differently from one who does not. He has a basis for explaining what he sees; that is, he can tell why something happens because he knows the conditions that are necessary to produce the effect which he observes. He can predict what will happen because he knows that certain conditions are followed by certain effects. He can bring about desired results because he knows the conditions necessary to bring them about. A person who understands a principle thus has the necessary basis for planning practical activities.

3. The third way in which modification of behavior may be obtained through science is *by developing the scientific attitude.* There are hundreds of superstitions fastened in the mind of the human race. Most of us are acquainted with people who firmly believe that breaking a mirror or walking under a ladder is a harbinger of bad luck. Probably none of these superstitions taken singly would seriously affect the life of any individual. Nevertheless, such beliefs are symptomatic of a condition that is very serious, namely, the lack of understanding of a most important contribution of science: a conviction of the universality of cause and effect.

A person who has the idea of cause and effect is entirely different from one who lacks this understanding. If he has this idea, he cannot possibly believe in superstitions, palmistry, or fortune telling by cards or tea leaves. All of these false notions fall down when examined in terms of a possible causal relationship.

This conviction of the universality of cause and effect is part of what is known as the *scientific attitude.* The holding of one's viewpoint as tentative until all the evidence is examined, the spirit of inquiry, and the habit of looking for problems to solve are also parts of the scientific attitude. A person in whom the scientific attitude has been developed has a distinct method of reacting to his environment—a method totally different from that of the person with no sense of scientific values.

Every available opportunity should be used to help children acquire the scientific attitude. Toward that end, they should be encouraged to become more observing, to look at a problem from every side before they express an opinion, to experiment carefully and accurately, to demand reliable sources of information, to withhold judgment until there is sufficient evidence to permit the drawing of conclusions, and to react intelligently to superstitious beliefs.

Children are vitally interested in science. As a result, they will ask many questions. This is a valuable part of the scientific attitude for both children and teacher. The teacher should not feel embarrassed if she does not know the answers to all of these questions. No scientist knows the answers to all the questions asked him. Any teacher of science will sometimes need to say to her pupils, "I do not know the answer, but I will be glad to help you find out." In fact, when the teacher knows the answer, she should not always tell it, especially if the question relates to something of basic importance. Rather, the teacher should help the children find the answer.

With such an attitude, the children and the teacher may solve coöperatively problems of mutual interest. A spirit of working together is most highly to be desired. The conclusions then seem doubly important, for the method of solving problems is no less important than the results obtained. Stimulate the pupils to do as much observing as possible. Let them examine things and arrive at their own conclusions. Try always to draw on their previous experience and on their observations made outside of the classroom.

4. The fourth way of modifying behavior is *by training in the scientific method of thinking*. The science class is the place *par excellence* for training pupils to become better thinkers. This is true because the generalizations of science are themselves the product of reflective thinking. It is possible in the science class to retrace, at least in part, the thinking through which the generalizations were reached. By using the experimental method of attack, we can set up situations where certain conditions are present and observe the effects produced. In the science class, pupils can make their own observations, draw their own inferences, and check the accuracy of their own conclusions.

5. The fifth way of modifying behavior is *by developing skills such as making observations, doing experiments, interpreting pictures and diagrams, reading science content with understanding, reading source materials,* and *using the instruments of scientists.* The *Basic Studies in Science* program includes a wide range of activities that are basic to the study of science. These are graded in difficulty so that each book in the program makes use of skills taught in earlier grades and then carries them on to higher levels of understanding and increased ability in their use.

Learning and Science Teaching

Conditions for effective learning

Methods of teaching must necessarily be based on the findings of psychology that deal with the learning process. These findings may be thought of as principles of learning that show the teacher what she must do to provide the conditions for effective learning. A brief statement of these principles and their application to methods of teaching science follows.

1. *Learning is most likely to occur when a child has a definite purpose to accomplish.* Instruction in science should be focused on a functional understanding of the generalizations of science that make the world meaningful. Somehow or other, we must make the acquisition of this understanding important to the child. It must meet some need that he has. Its acquisition must result in some satisfaction to the child. In other words, the understanding must solve some problem that he wants to solve, answer questions that he wants answered, or show him how to do something that he wants to do.

Application of this principle of learning must be made when starting a new unit or a new problem. It is a matter of setting the stage for learning. There are various ways of doing this. See pages 12-14 of this *Guidebook*.

2. *Activities must be set up that produce some active response by the child.* In science, we are concerned with certain understandings. We are trying to teach certain concepts that will help the child in his adjustment to the world in which he lives. Now a person cannot just learn an understanding. An understanding is obtained only when he does some thinking. Furthermore, if he acquires an understanding, it must be a product of his own thinking. We are all familiar with the saying, "We can't learn pupils, we can only teach them." In other words, as teachers, our task is to set up a learning situation in which pupils carry on certain activities focused on the understanding. The

pupil learns as he carries out the activities. The understanding that results is the pupil's. It is a product of his own activity. What the pupil does, therefore, determines what learning, if any, will occur. In general, the more active the participation of the pupil in deciding what should be done, the more purposeful the activity will be and, therefore, the more likely it will result in the desired learning product. The types of activities will vary with the learning product to be attained and with the kinds of materials available in the classroom.

This *Guidebook* is concerned primarily with the more effective use of the textbook. Suggestions for setting up desirable activities using text materials with different types of organizations will be found on pages 14-16 of this *Guidebook*. There are also many suggestions for doing experiments, taking field trips, etc. These suggestions will be found for the most part on pages 13-16 of this *Guidebook*. A discussion of "Using the pictures in the book" will be found on pages 17-18.

3. *Learning, to be effective, must be based on the experiences that the child has had or is having.* This implies that new concepts must be based on an adequate background of first-hand experiences. The more closely related the first-hand experiences of children are to the concept that is being developed, the more meaningful the concept will be. This principle is especially important in starting new units or new problems. Suggestions for its application are given on pages 12-14 of this *Guidebook*.

4. *The learning activities must be adapted to the individual needs of the child.* This means that a wide variety of activities should be carried on. Different activities attack concepts from different angles and thus obtain greater depth of meaning. Furthermore, some methods of development are more effective than others for different children. Reading, doing experiments, making observations, interpreting pictures, planning ways of finding out things, etc., call for different types of thinking. A many-angled approach is most likely to provide activities that are appropriate for children with different interests and abilities. Suggestions for different types of activities are included on pages 12-19 of the *Guidebook* and also in the procedures suggested for each unit.

5. *Learning, to be retained, must be used.* This principle has two implications. In the first place, it implies that activities must be set up which require the pupil to use the concept as a basis for explaining things around him and as a guide for practical activities. Only through use does the child acquire an understanding and the ability to use this understanding in his daily life. The more closely the kind of activity set up is related to the kind of situation that is met in daily life, the more likely it is that the learning will transfer to daily living.

In the second place, the principle implies the necessity for constant use of the concept and its reinterpretation in the light of new experiences. Old concepts must be constantly related to new concepts so that a continuous reconstruction of experience can take place.

In the pupil's book, common situations in the lives of children are used to introduce children to the problems. The examples applying the concepts are also of this type. In this way, the concept is related to life itself. Questions that children usually raise about the concepts are raised. Then the children are shown how to use the concepts to answer these questions or to do other things. The teacher should know what kinds of questions to ask children. Various types of questions will be found in the discussions of the different kinds of activities on pages 12-19 of the *Guidebook*.

The teaching cycle

The teaching cycle, to be effective, must parallel the method of thinking to be used in the learning cycle. It must insure that the child actually follows through the steps in thinking. This is done by setting up appropriate activities in each step of the cycle.

The principles of learning may be made more specific by showing how they are applied in teaching a generalization of science.

1. *There must be a stimulus to initiate learning.* In science, the stimulus must present a problem, because an understanding is obtained only through thinking. To present a problem, the situation must be meaningful to the learner; that is, it must be connected with some experience he has had or is having; and the situation must be sufficiently concrete and interesting to challenge the pupil to find a solution. Solving the problem is the purpose in the mind of the child. Ways of raising problems in the minds of pupils are discussed under "Starting a new unit or problem," page 12 of the *Guidebook*.

2. *There must be a period of assimilation or experience getting.* Pupils are sent to their textbook and other books, experiments are performed, field trips are taken. In fact, all sources that will supply needed facts and experiences are used. This period will always culminate in activities that require the pupils to generalize. Suggestions for using the book, performing experiments, and carrying on other activities are included on pages 12-19 of the *Guidebook*.

When a pupil has made the generalization, he has arrived at the point where he catches the idea; that is, he sees the relationship vaguely. If left at this point (and many teachers allow this to happen), he has not attained real learning. Therefore, the next step is extremely important.

3. *The generalization must be made meaningful.* This is a period of teacher-pupil activity in which the teacher tries to show some of the applications of the generalization: (1) how to use it, (2) where it is used, and (3) when it is used. In the text, applications of the generalization follow the development of the generalization. They take the form of new examples or problematic situations that are solved by use of the generalization. The specific suggestions for each unit provide additional examples to help make the generalization clear. This concludes the part of the teaching cycle in which the aim is to get across the understanding.

4. *Practice in the use of the new understanding must be provided.* The pupil must be provided with situations in which he uses the generalization for predicting, planning, and explaining. Since the understanding does not function unless it transfers to daily life, the situations must be common in the environment of the child. The greater the number of these situations, the more likely that the generalization will be functional in actual life. The questions at the ends of problems and units help provide these situations.

As a result of this step, the pupil arrives at a point of functional understanding. He can now use his understanding in situations appropriate to his level of development. In other words, he has arrived at a point of intelligent behavior. This method of developing a functional understanding is the method of thinking used by anyone who really carries on a complete act of thought.

Organization of this series

The *Discovering Our World* series is the result of a definite demand from teachers for a well-balanced, organized course in science, focused on acquiring meanings that will function in intelligent living. It is not just a collection of facts about bees, butterflies, and beavers. Interesting though these facts may be, they are not sufficiently general in their meaning to provide a basis for explaining the world or for solving our everyday problems.

In this series, the content is definitely focused on the acquisition of general meanings. These general meanings are developed by the problem method of attack. Problems, or questions, arise from, and thinking starts with, doubt or perplexity. A person has something to do or something that he wants explained; but he does not know what to do or how he can explain away his perplexity. This starts his mind searching for a way out of his difficulty. He begins to think. In general, the pattern of effective thinking is as follows:

1. Recognizing the problem to be solved.
2. Recalling experiences that may help to solve the problem.

3. Searching for new facts that may bear on the problem.

4. Evaluating the suggestions that come to mind and selecting the one that appears most promising.

5. Testing the suggestion for its truth.

6. Drawing a conclusion and testing the conclusion for its truth in other situations.

If study materials are to help pupils do better thinking, the materials must be organized and the ideas developed in such a manner that they follow this general pattern of effective thinking. For this reason, the problem method of attack has been used throughout the series.

Each unit deals with a major problem in the environment of the child. The unit, or major problem, is then broken down into minor problems. The solution of each minor problem is essential to, and leads toward, the solution of the major problem of the unit. A glance at a unit and its subdivisions in the table of Contents (pages 3-5 of the pupil's book) will show this. The child is confronted with a major problem. To solve this problem, he must think through minor problems. As he acquires an understanding of the generalizations and principles involved in each minor problem, he is building up an understanding of the major problem of the unit.

Each new idea in *Discovering Our World* is presented in such a manner that it becomes a problem for the child to solve. The text says to the young learner, "You have seen this happen, or you have had that happen to you. Now let's see if we can find out why it happened. First of all, just what did happen, and what were the conditions under which it happened?" This is no didactic, passive approach to learning. It is a pupil-activity, problem-solving approach: "Let's do something to see what we can find out in answer to our question." That is the spirit and the method of presenting and developing new ideas in the *Discovering Our World* series.

This treatment of science principles leads the child inductively, by experiments and observations, toward the acquisition and understanding of the principles. At every step, the spirit of problem solving, the spirit of discovery, is maintained. The organization, pictures, experiments, observations, exercises, and activities in the books of this series are focused on two objectives: (1) the development of meanings and (2) the development of better methods of thinking. This focus is maintained by a teaching technique based on problem solving. A child cannot *memorize* his way through these books; he must *think* his way through them.

How to Use This Book

Fitting the book to local conditions

The pupil's book includes enough material for those schools where full time is allowed for science as an established part of the curriculum. In such schools, the pupils probably will cover all of the units, including the questions and activities suggested. They may further enrich the science course by doing outside reading and engaging in additional activities according to their own interests.

In many school systems, science is introduced in the first grade. Children will, therefore, have many concepts that contribute to the understanding of the concepts presented in the text. To assist teachers in discovering this background, the authors have listed at the beginning of each unit, the background units found in the earlier books of the *Basic Studies in Science* program. Reference to these books will give teachers an idea of the experiences on which they can build the new concepts. Teachers are urged to become familiar with the concepts taught in preceding grades. In many cases, recalling these earlier experiences will bring about a decided saving in time. Furthermore, it will help pupils reinterpret these earlier experiences in the light of the more comprehensive concepts presented in the later grades.

In schools where time is limited, it may be necessary to shorten the course somewhat. This can best be done by covering some units rapidly, without stopping for detailed development, while others may be more carefully developed with all the suggested activities carried out. However, it is not wise to omit units or parts of units. A unit that is unrelated to others within a book may be necessary for the understanding of concepts presented in later books. For example, in Book One the unit on magnets (Unit 6) is not related to other units of Book One. But an understanding of magnets is presupposed in the unit on energy (Unit 2) in Book Two and in the unit on electric current (Unit 5) in Book Three. The section "Science background" in Part Two of the *Guidebook* shows the interrelationships of the units in the series. The series has been carefully planned as part of an organized program in science and is most satisfactorily used as such.

General suggestions for teaching the units

Many teachers have had little or no experience in teaching science. Yet science is not difficult to teach. First of all, children are vitally interested in science. This, of course, means that half the battle is won. The method used in teaching science is not greatly different from that used in other subjects where understanding of certain concepts is the goal. However, science teaching makes greater use of observations, field trips, and experiments than is ordinarily made in other subjects. The science activities in the middle grades are very simple. The equipment consists of easily available materials. The directions given in the text, together with pictures that show the materials used and how they are put together, are so detailed that a teacher who knows little or nothing about science will have no difficulty in doing the experiments or carrying out the other activities.

Needless to say, the ideal learning situation is one in which the teacher enlists the active coöperation of her pupils in planning and carrying out the activities of the various units. The following general suggestions will be helpful in achieving this ideal situation. (Specific suggestions will be found in Part Two of the *Guidebook*, which deals with individual units.)

1. Interest pupils in an active program of observing and collecting as much material as possible from their surroundings.
2. Encourage boys and girls to suggest additional experiments, field trips, and observations.

In this section of the *Guidebook*, the authors have set up general principles for using the book and for carrying out the types of activities suggested in the book. These general principles should be applied in teaching specific units. Once a teacher understands the general principles and sees how they are applied in concrete situations, she will soon gain skill in applying the principles in new lessons. Of course, many teachers do not need a discussion of this type. This section is written especially for those teachers who are a little uneasy about their ability to teach science.

Preparing to teach

First of all, the teacher must have clearly in mind the science generalization that she is trying to teach. She can use the list of concepts in Part Two of this *Guidebook* to find out what these important generalizations are. As she uses the text, she must learn to differentiate between the facts, examples, and other assimilative materials and the generalization itself. An inexperienced teacher may easily fail to do this. Therefore, she does not see that the text is focused on getting across a certain concept. As a result, the activities set up in the classroom lack focus because the teacher has none. As a first step in preparing to teach, therefore, the teacher should find out what is the big idea, understanding, or generalization that she is supposed to get across. To help her see what the general concepts are, the authors have listed them at the beginning of each unit. In addition to this, the authors have listed the concepts for each subdivision, or problem, of each unit.

With her *Guidebook* open to these lists, the teacher should read through the unit as a whole and again through each problem before presenting it. She will then have a clear idea of the scope of the unit and also of the contribution that the concepts in each problem make to the unit as a whole. She will also have a clear picture of the relation of the observations, experiments, and other activities to the development of the concepts. She will be able to plan ahead for time and materials when necessary. Specific suggestions for planning ahead will be found in the sections called "Procedure" in Part Two of the *Guidebook*.

During the initial preparation for teaching the unit, the teacher should also look ahead to the additional activities suggested in the "Things to Do" sections at the ends of the units. Some of the activities are related to the unit as a whole. Others pertain to certain problems and are referred to in the procedure for the problem. Since it is better to use these activities throughout the unit rather than to wait until the unit has been completed, the teacher should look ahead and plan for the ones that she can use.

Second, the teacher must find out what experiences the children have had that can be explained by the concept. By questioning the class, the teacher should be able to discover just how far the pupils have advanced toward an understanding of the concept. However, if they have had no appropriate experiences, the concept cannot be taught until such experiences have been acquired. An experiment, observation, or field trip will often provide the needed experiences.

Because of the limited science training of many elementary teachers, the authors have included some of the technical science background behind the elementary presentation of the text. This will be found in the sections entitled "Information for the teacher" in Part Two of the *Guidebook*. Teachers should also consult standard high-school texts in biology and general science. These will give the desired information without going into needless technical detail. They will also give some additional background as a preparation for teaching the unit.

General procedures

Starting a new unit or problem

The first teaching situation met in a new unit or problem is naturally that of deciding how to get started. Shall I have the pupils read the introductory section first? Shall I raise some questions before sending them to the book? If so, what kinds of questions shall I ask? Shall I start with a field trip or a demonstration? Shall I tell them a story? What shall I do?

As pointed out earlier in this *Guidebook*, learning begins when the pupil starts to think. His thinking starts when he is faced with a situation in which he is not certain of exactly what to do or when something happens that he does not understand and he wonders "Why?" or "How?" In other words, thinking starts with a doubt or perplexity. There must, however, be more than a perplexity; the pupil must also want to do something about it.

All of this means that the pupil must have a question before he will begin to think and that he must want to answer this question. To start a new unit or problem, the teacher must be certain that the pupil has questions which he wants answered. He may want to find answers to his question because he sees their use value or because they provide for some definite need or simply because his interest is challenged and he wants to know. Any of these reasons are equally good for raising questions. The important thing is to be certain that the child has some questions which he wants answered.

Questions arise when a person is in doubt. No concrete question can arise, however, unless it is related to some past experience or present experience. This is true because the meanings that we have are the results of our experiences. Without experiences to give us meanings, we cannot have questions because we do not know enough. We can only be confused. We cannot put our finger precisely upon the perplexity, and so we cannot start to think. To start a new unit or problem, therefore, the teacher must relate the unit to past experiences of the pupils or to experiences that they are now having. These experiences must lead into questions that the children cannot answer. Here are some of the methods in which a new unit can be started. (Most of these methods can also be used to start new problems within the unit.)

1. *Ask questions about experiences that the pupils have had which may be related to the unit.* To use this approach, first make a list of what children have probably seen, heard about, read about, or done. Then ask questions such as: "Did you ever see——?" "What did it look like?" "Have you ever heard about——?" "Did you ever make a——?" "Did you ever watch someone——?" The purpose of these questions is to get some facts from the pupils' past experiences. The questions will also bring to light experiences that the pupils would never voluntarily recall because they would not see the relation of the experiences to the new unit.

Now you are ready to raise questions. Accordingly, ask questions about the "how" and "why" of these experiences. "How do you explain this?" "What made this happen?" "Why did you do——in this way?" Use questions such as these to push the pupils back further and further until you come to explanations that they cannot make. Write on the board questions that they cannot answer under the heading *Questions We Cannot Answer.*

With these questions in mind, the children can read the introductory section of the unit to see if they can find any answers to their questions. Often the introductory section raises new questions. If the children cannot answer them, they should be added to the list on the board. (Example: Unit 2, page 45.)

2. *Compare experiences of pupils with experiences presented in the text.* The introductory sections of some units present experiences that are used to raise questions. If children have had similar experiences, ask questions about them. Have the children tell how they did a certain thing or describe something they have seen. If a series of steps is involved, write them on the board.

Then refer children to the book and say, "Here is a story that tells you how someone else did this." Have pupils read to find out what was done. Tell them you are going to ask them to tell the class, step by step, what was done. Write these steps on the board. Then have pupils compare these steps with the steps that they have listed. Then ask for reasons for the various steps. This should result in questions that the pupils cannot answer. (Example: Unit 3, page 71.)

3. *Use pictures to start discussion of the unit.* Have pupils read the unit title. Then ask questions about pictures in the unit that will lead into the first problem. (Example: Unit 9, pages 221-245.)

4. *Have pupils read the unit title.* Then ask them to read the problem titles to find out what kinds of questions are to be answered. Write the problem titles on the board and ask pupils what they think the answer to each one is. This procedure will help create interest in the unit and at the same time will give an idea of the scope of the unit; it may be used with almost any unit. (Example: Unit 6, pages 149-168.)

5. *Use the introductory section to initiate activities that will result in a question.* In some of the units, the introductory section sets up activities that will raise questions. The text describes how a group went about finding an answer to a question. First, have pupils read the unit title. Then tell them that the introductory

section tells what one group did to get started. Have them read the section to find out what this group did. Next, ask questions about what this group did. Then have the pupils plan how they can carry on the same activity. After the materials have been brought in, raise the questions to be answered in the first problem. The pupils should now be asked to tell what they think should be done to answer the question. Then compare this solution with the method suggested in the text. (Example: Unit 6, pages 149-150.)

6. *Do some experiments.* (These can be experiments suggested by the book or experiments not in the book. The purpose is to raise some questions.) A good way to start a unit is to get some facts that require explanation. This method is often used in the text. Have the pupils read the unit title. Then tell them that the introductory section tells how to do an experiment to get some facts. Ask them to read the section to find out how to do the experiment. Next, have the children tell how to do the experiment or have some member of the class do the experiment. Then make a list of the facts brought out by the experiment. Call for explanations of these facts. Make a list of questions about facts that cannot be explained. (Example: Unit 4, page 103.)

7. *Take a field trip to get some facts to explain.* Whenever possible, the pupils should get facts by first-hand observation. Since the units in this book are related to common environmental situations, children can often be taken on walks or trips where they can make observations and thus get facts that call for explanation. To find out what to observe and what kinds of questions to ask, read the problems of the unit and note the pictures and their legends. Then take a walk yourself to find out what things can be seen. Make a list of the things and the questions you can ask about them. (Example: Unit 1, pages 11-13.)

Using the text to get ideas needed to answer questions

In general, the text uses three methods of organizing the study material: (1) It may tell how one class answered the question. (2) It may answer the question by telling the pupils how to carry on certain activities. (3) It may answer the question by straight exposition. The method of using the text will necessarily vary with the method of presentation used in the text.

1. *The text presents a class discussion.* In this type of presentation, the text presents a running account of a classroom discussion. This method is used principally in the opening unit of the book to show how a science class might be conducted. The teacher asks and answers questions; pupils answer questions and ask questions; the teacher guides the discussion toward an understanding of the concepts that she is trying to get across by her questions and her follow-up of the pupils' answers. This type of presentation has several purposes.

First, it presents a pattern for carrying on a discussion in a science class. Teachers who have had no experience in teaching science will find it profitable to read through several lessons of this type to get a better idea of the kinds of questions asked by the teacher to keep the discussion going and the ways in which the pupils are brought into the discussion. Note that the pupils are asked to suggest ways of doing things and that these ways are discussed and evaluated by the pupils.

Second, the children, as well as the teacher, must learn to participate in a classroom discussion. Unit 1, Book Two, is developed largely by this method so that pupils may be introduced to the type of thinking that goes on in a science class. The teacher might well say, "The class described in our text is carrying on a discussion. Let's see how they do this so that we'll learn how to discuss, too."

Third, presentation of this type adds interest to the text because children are interested in what other children do. They are also interested in carrying on the types of activities suggested in the text.

Fourth, this type of presentation permits a slow and easy development of the concepts.

Each step in the development of the concept is included. The children can easily follow the thinking of the class and see how the class arrived at the concept. There are several methods of using this type of material; the method to be used depends on the way in which the material is developed and the purpose.

a) The purpose is to initiate an activity in the class. To do this, the text describes what one class did. For example, let us suppose that pupils have brought various kinds of things to school. The teacher raises a question, "How can we find out more about these things? Let us see what the class in our text did." After the pupils have read the text to find out what the class did, the teacher asks questions such as: "What was the class trying to find out?" "What did they do to answer the question?" "Why did they decide to do this?" "Could we do this?" "How could we do this?"

As can be seen from the questions, the major purpose is to show the pupils what they can do. The suggested activity should be carried on whenever possible. While it may be possible to get an understanding merely by reading and discussing the text, there is no substitute for actual experience. Note that the questions asked by the teacher call for more than repeating what the text says. They raise questions about the "how" and the "why" of the activity. (Example: Unit 5, pages 126-129.)

b) Sometimes it is better to raise a question and either suggest or have the pupils suggest what they might do to answer it. Then have the pupils go as far as they can in answering the question. The children can then be referred to the text to find out if the class described answered the question in the same way or in a different way. Then have the children find the ways in which their answer was like or different from what the class in the text found. (Example: Unit 1, pages 13-18.)

c) As a rule, pictures are included that show how the class described carried on the activity or that show the finished product of their activity. The teacher asks questions such as: "What is the class doing?" "Why are they doing this?" "Can we do this?" "How did they do this?" before the pupils read the text. Rediscussion of the pictures on the basis of what the pupils find out can follow. (Example: Unit 2, page 54.)

2. *The concepts are developed by raising questions and answering these questions by making observations and doing experiments.* Science differs from the other subjects studied in the elementary school in that the questions which arise can be answered by observation and experiment. Through the use of these two activities, the pupils can get first-hand information. They can then base their thinking on facts that are meaningful to them. Throughout this book, experiments and observations have been introduced wherever possible. This has been done for two reasons: (1) because all learning focused on understanding must be based on a background of perceptual experiences, that is, on information that the pupil can get with his own senses; and (2) because pupils should acquire the attitude, "If we have questions or want to find out about something, we can do experiments (or make observations) that will answer our questions."

Experiments and observations are introduced in this book to provide facts that are needed to answer some questions. A statement in the text is made more meaningful by doing an experiment or making an observation. Or the experiment is done or the observation made to answer a question that has been raised in the text just preceding the experiment.

Before the text is read, the teacher should (1) raise questions about past experiences of pupils such as were suggested in the section dealing with starting a new unit and (2) raise the question that the experiment or observation is to answer. Then ask the children, "How can we do an experiment to find out?" (It is always good practice to have children suggest possible ways of doing an experiment. Many of them may be good enough to try.)

Now that the question is raised, the children can be referred to the book for directions. The teacher can say, "Our book tells us how to do an experiment to answer our question. After you read the directions, I am going to ask you to decide what to do." Write *What to do* on the board and then have the children tell what directions to write.

Make the directions as brief as possible. If a simple diagram can be made, have pupils tell how to make the drawing. If they do not know, show them. This is valuable because pupils have to learn how to interpret diagrams. Practice in making diagrams will help them learn how to interpret diagrams.

Now ask the pupils what they think will happen. Get them to predict. This is effective because (1) you can ascertain from their answers whether or not they understand what is going to be done; (2) you can see if they know what to look for; (3) you can make them commit themselves and make them interested in seeing whether they are right or wrong.

Next, get them to understand what the experiment will show if a certain thing happens when the experiment is performed. Ask them, "If——happens, what will this show?" Then do the experiment. Write on the board *What happens*. Have the children decide what to write. Then raise the question, "What does this seem to show?" Write *What the experiment shows* on the board. Have the children tell what to write.

Whenever possible, the step of verification should be used. Ask, "Is there any experiment we can do to prove that we are right?" In many cases, such an experiment is included in the text. If this is the case, have the children read the experiment and record the results under the steps already listed. Then have the children work out a conclusion. The conclusion should answer the question and give reasons for the answer.

After all of the experiments have been performed, raise the questions, "What facts do our experiments give us that we can use to answer our question?" "What facts does the book give us?" The facts from both sources should be incorporated into the answer for the problem. (Example: Unit 2, pages 59-61.)

3. *Concepts are developed by raising questions and answering these questions through presentation of reading material of a descriptive nature.* Whenever possible, experiments and observations are used to develop the science concepts. Sometimes, however, it is impossible to provide experiments that are sufficiently simple to be carried on by middle-grade children or that do not require laboratory facilities beyond the resources of the elementary school. It is equally impossible to provide for actual observation of all living things in their natural habitats. Accordingly, the text must provide factual material based on the observations of scientists. It should be emphasized that the facts have been acquired by experimentation and observation. This point of view can be developed by asking such questions as "How do you suppose that scientists found out about this?" "What might we do to prove this?" "Why can we believe that this is true?"

The method of developing the concept, of course, depends on the kinds of concepts that are being developed. For example, if the content is focused on showing the children how some device works, the development will be somewhat as follows: (1) what the device does, (2) how it is put together, (3) how it is made to work, and (4) an explanation of what happens when the device is operated. If the content is focused on the development of the characteristics of a group of living things, materials, etc., various members of the group are described; and then the characteristics common to all members of the group are discussed. If the concept is focused on some relationship, specific examples of the relationship are presented; and then generalizations are made about this relationship.

The pupil's book provides the necessary information. It should be pointed out here that the facts included in the book are a means to acquiring the concept. The ability to repeat verbatim what the book says does not necessarily mean that the child has acquired the idea. Suggestions for developing the concepts are found under the heading "Procedure" in each problem of the *Guidebook*.

Using the pictures in the book

In *Discovering Our World, Book Two*, as in all the books of the *Basic Studies in Science* program, the pictures are functional. They are an essential part of the method of developing the concept. Each picture has a definite purpose to serve. For example, some pictures are used to raise questions, some are used to show steps in a process, some are used to show how an experiment should be performed, some are used to supply additional applications of a process, and some are used to provide for practice in interpreting. Pictures may be a substitute for the actual experience. They make it possible for the child to experience vicariously the experiences that others have had. They bring the near and far environment into the classroom.

To use the pictures effectively, the teacher must study each picture to see how it can be used to assist in learning. First, she should understand what the purpose of the picture is. Then the question is, "How can the picture be used for this purpose?" This is a matter of determining what questions to ask about it or what activities to set up that will make the picture serve its purpose. The following examples show how to use pictures in this manner.

1. *Using pictures to raise questions.* Pictures used for this purpose usually have the legend in the form of a question. The problem may be introduced by asking pupils to look at the picture and answer the question. Then they may be directed to read the problem title and the text to find out if their answer to the question was correct. The original answer can then be corrected in light of what they have found out from their study. If the original answer is incorrect or partially incorrect, the children should be asked why it was incorrect. (Examples: Unit 2, pages 49, 51, 113.)

2. *Using pictures to show how to carry on some activity.* The text describes an experiment to perform or an observation to make. The picture shows some children carrying on the activity. The purpose is to help pupils see how the activity is carried on. There are several ways of using these pictures.

a) Have the children read through the directions in the text. Then refer to the picture. Ask questions such as: "What things is the boy using?" "What is he doing?" "What is he trying to find out?" "Can we do this experiment?" "What shall we do?" (Example: Unit 3, pages 82-86.)

b) After the question is raised, have the children look at the picture before reading the text for directions. Then ask questions such as those above. Then have the children read the text to find out more exactly what the boy is trying to find out, what materials he needs, and what he is doing. (Example: Unit 4, page 107.)

c) Sometimes the materials and equipment in the picture may not be available in the school. In this case, the picture can be substituted for the direct experience. In some cases, other kinds of materials or equipment can be used. Ask children how they might do the experiment with other equipment that is available. (Examples: Unit 4, page 105; Unit 5, pages 136-137.)

Often the pictures merely show the apparatus needed and methods of constructing the apparatus. It is necessary to refer to the text to find the directions for doing the experiment. Ask questions such as: "What do we need to do the experiment?" "How shall we put the parts together?" "What do the pictures tell us to do?" Examination of the picture should be followed by having the pupils read the text to check the information that they get from the picture. (Example: Unit 9, page 223.)

3. *Using pictures to make graphic a concept developed in the text.* Without a picture, description is often difficult to understand. Pupils cannot always visualize what is described. Pictures also make it possible to show things that the child has not experienced or could not experience in his everyday environment. For example, the pictures on pages 34 and 35, Unit 1, show the sequence of events. Questions about

the pictures should connect what is shown to the concept. Questions such as the following can be used: "What do these pictures show?" "What does the book tell us about these pictures?" "What do these pictures show about plants?"

4. *Using pictures to obtain interpretation on the basis of a concept that is presented.* An essential part of all learning is use of what has been learned. Use of a concept in the interpretation of a picture helps make the concept more meaningful. Many pictures of this type are included in the book. Usually there is a legend with a question. Or a question may be included at the end of the problem. (Examples: Unit 3, page 77, No. 1; page 87, legend under picture; page 100, No. 1; page 92, legend over picture; Unit 5, page 146, Nos. 3 and 9.)

Without the use of pictures, it is almost impossible to teach how a device is constructed. Children find it difficult to visualize a long description of the parts of a device and the relation of these parts to each other. The following questions will help pupils analyze the device and see how it works: "What is the name of the device?" "What does it do?" "What are its parts?" "About how large is a real device of this kind?" "When this part moves, what does that part do?" "What are the different steps in its operation?" "What happens in each step?" "How can we explain what happens?" "Where is this device used?" "Who uses a device such as this?" "Have you ever used a device like this?" "What for?" "How should the device be taken care of?" (Examples: Unit 2, page 54; Unit 3, page 88.) Pictures of parts of plants and how they work are used in this way also. (Examples: Unit 8, pages 210, 213, 215.)

Using the questions at the ends of problems

The questions found at the ends of the problems also are focused on the important concepts. The final step in each problem is to have the children answer the questions raised at the beginning of each problem. Usually, it is worthwhile to write an outline answer on the board. The outline should be developed by the children. In general, it should correspond closely with the outline of concepts presented in the *Guidebook*. If children fail to include a certain concept, the teacher should raise questions that will bring out the concept. For example: "You remember we read about——. What does this show? How do these facts help us answer our question?" Or the children may be asked to reread some part of the problem and the questions above may be asked.

The activity at the end of each problem is a generalizing activity. The children must be led to see that the facts presented in the book are important because they enable the children to get ideas about things that can be used to find out more about other things. For example, when the pupils find that mammals have certain characteristics, these characteristics tell them about other mammals and also help them decide if a certain animal is a mammal.

The questions at the ends of problems are of two types. The first of these two types is designed to test the child's understanding of the study material. Questions of this type can be answered if the child understands what he has read. They correspond roughly with the questions used to test reading comprehension in standardized tests. The second type of question calls for some thinking on the part of the child. It may require the recall of experiences similar to those presented; it may call for classification of objects or events based on certain group characteristics; it may call for the interpretation of a picture on the basis of some concept that has been studied; it may call for comparisons; or it may call for reasons for carrying on an activity in a certain way. These questions are designed to give the children practice in the use of the concept.

The questions may be used in several ways. After the problem title has been read, the children can be referred to the questions at the end of the problem to find out what they must be able to answer after they have studied the text. It is often desirable to have them try to answer the questions before the text is studied. After studying the text, they can compare their original answers with the ones that they now give. This method of study shows the children that they have learned something; they can answer questions that they could not answer before.

Or the text may be studied before reading the questions. Then read the first question to the children and call for an answer. This may be given orally or sometimes in writing. The teacher should distinguish between the information-type questions and the application-type questions. Children are accustomed mainly to questions that can be answered directly by the recall of something which they have studied. When an application-type question is asked, they should be told that they will have to think out the answer because it is not in the text. Occasionally, when they cannot get started on the answer, the teacher may have to ask them what they learned from their study. This might be written on the board. Then say, "How does this help us answer our question?" They must understand that what they learn can be used to answer other questions.

The information-type questions at the ends of the problems can also be used as a basis for a summary. First, write the problem title on the board. Then call for the answers to the questions. Write the answers on the board as briefly as possible. Then help the children condense the answers to the different questions into a single answer to the problem.

Using the "Questions to Answer" at the ends of units

The "Questions to Answer" at the ends of units are so stated as to require a broader association of meanings than is called for by questions at the end of each problem. They call for integration of ideas obtained from different problems and for interpretation of situations on the basis of ideas obtained from the whole unit.

The "Questions to Answer" should be discussed after the problems of the unit have been completed. Children should learn to give evidence for their answers. One method of stressing this is to have children be prepared to cite references in the text, which they used as a basis for their answers. When they start finding the answers to the questions, tell them to look back through the unit and find a paragraph, a sentence, or a picture which they can use to prove that their answer is correct. Then ask them how this reference in the text can be used as proof for their answer.

Since some of the questions are of the application type, children may sometimes have difficulty in answering these questions because they fail to see the connection between the text and the question. If this happens, refer them to the part of the text dealing with the idea basic to the solution. Have them read it over and then ask, "How can we use this idea to help us answer our question?" Every question in the book can be answered by using what the children have studied.

Using the "Things to Do" at the ends of units

The "Things to Do" at the ends of units suggest activities that make more meaningful the ideas in the units and bring about a closer tie-up with the environment. Usually, the activities should be assigned to individuals or groups on a voluntary basis. Some time should be spent in class, planning how an activity should be carried out. This should be as nearly pupil activity as possible, for the planning has the greatest value. Sometimes a group can be instructed to plan what they intend to do and then report back to the class on their plans. Then the plans can be evaluated and changed by the children. In this way, all the children will learn how to plan science activities; and they will get a better insight into the method used by scientists.

Part Two SUGGESTIONS FOR TEACHING THE UNITS

This part of the *Guidebook* gives specific information and suggestions for teaching the individual units. If the teacher has read Part One carefully, she has become acquainted with the general suggestions for handling the various types of teaching situations that will arise in teaching the units. As she comes to these situations (starting new units or problems, doing experiments, etc.) she should refer to the appropriate section in Part One. Application of these general suggestions, together with the specific suggestions that are given for the section being studied, will help the teacher approach the situation with confidence.

Using the Introduction (Pages 6-9)

If pupils have had science work before, they may be asked to read these first pages and discuss such questions as: "What do you think 'discovering our world' means?" "How can you find answers to the problems in science?" "What are some cautions we will need to use in reading this book and in using other books?" "What are some rules that we should follow in performing experiments?"

The method of using these pages will depend on the previous science experience of the pupils. If there has been no earlier contact with science, frequently the best attack is one that assumes that the pupils know nothing of the subject itself and then proceeds to find out what experiences the pupils have had that will be helpful as an introduction.

These pages should help orient the pupil to the subject of science if he has had no previous acquaintance with it, or they should expand the horizon of science experiences that he may have had in earlier grades. The discussion in these pages introduces the concept of what science is, who scientists are, and what their methods are. If there has been no earlier science experience, the first class sessions might well be spent letting pupils express themselves on such questions as these: "What do you think science is about?" "What do you think a scientist does?" "Do you know any important things that scientists have discovered or invented?" "How can anyone in our class ever become a scientist?"

Encourage the pupils to try to solve the problems listed on page 7. This will create interest, point out the limitations of the pupils' knowledge, raise new questions, and lead into the text of the book. Following this, the study of the book may be approached in some manner as: "Our book will help us discover some of the things that scientists have found out about these problems. It will also show us how scientists have found the answers to these problems and many others. If we look at the Contents, pages 3-5, we can see just what our book tells. We may also look through the book and see the chapter headings and the pictures."

Note, on page 9, the reference to the list of *Science Words*. The pupils should become acquainted with this feature of the book, but instruction in how to use the list may be deferred until the occasion for its use arises.

UNIT 1. *How Do Living Things Help and Harm Each Other?*

Purpose and scope

Through a study of this unit, girls and boys will become more keenly aware of the interrelationships of the living things around them. There are many opportunities for them to make first-hand observations that will increase their appreciations of the living things that surround them. It is through an understanding of the habits of these living things and through learning about them that children can come to believe in the importance of conservation of living things, which is one of the most essential purposes for studying the unit. Other aspects of conservation are emphasized in later units of the textbook. The concepts indicated at the beginning of each problem will act as a guide to the teacher in helping her emphasize the important aspects of the total problem of the unit. These concepts take on real meaning for pupils as they observe the many examples in their surroundings, if the teacher makes sure that the children see how their experiences are related to the concepts. Field trips and all other kinds of first-hand contacts with the living things around them are then very important to the realization of the purposes for teaching this unit.

Science background

Look and Learn: Unit 1, Animals; Unit 4, Outdoors

All Around Us: Unit 1, Animals; Unit 4, Plants

How Do We Know?: Unit 1, Animals; Unit 3, Plants

Discovering Our World, Book One: Unit 1, How Are the Things of the World Put in Groups? Unit 2, Why Do All Living Things Need Air and Water? Unit 8, How Do Animals and Plants Grow?

General concepts

1. Animals help other animals.
2. Plants help animals by providing food and shelter.
3. Animals help plants.
4. Plants help other plants.
5. Plants and animals harm other living things.
6. Plants and animals are valuable to us.
7. We should help conserve the living things that are valuable to us.

Introducing the unit (Pages 11-13)

Information for the teacher

PICTURES. PAGE 10. These animals are snow leopards that are found high in the Himalaya Mountains between Tibet and India. They have caught a pheasant for food.

PAGE 11. The illustration at the top of page 11 shows various ways in which plants and animals are interrelated in nature. Animals use plants for food (squirrel and porcupine); animals use other animals for food (robin and hawk); plants use other plants (bracket fungi on stump).

Porcupines usually climb into the higher branches of the tree to find the buds, small twigs, and younger and more tender bark, although they also gnaw the bark closer to the ground.

PAGE 12. If the bark is eaten or otherwise completely destroyed around the trunk of a tree, the tree will die. The tree is said to have been girdled. Since the food travels down to the roots through the inner bark, the roots die if this passage is interrupted by girdling. When the roots die, of course, the whole tree dies.

TEXT. PAGE 11. The first stage of a clam is really a larva and does not look at all like the adult. It has a shell armed with tiny hooks, which open and close continually. The fish takes in water through its mouth and expels it through its gills. When the clam larvae enter with the water and touch the gills, they attach themselves to the gill fringes. The larvae remain on the fish gills for several weeks. Finally, they drop off into the water and develop independently.

Procedure

The pictures on pages 10 and 11 might well be used to introduce the unit by asking the children these introductory questions: "What two kinds of living things are shown in these pictures?" (Plants and animals.) "How many examples of plants and animals helping and harming each other can you find in these pictures?" After some of these have been listed, ask a child to read the question that introduces the text on page 11. Let pupils give their ideas of how this could be possible. Next, suggest that the class read the paragraph. Then pupils may be asked to tell why they believe the clams were disappearing. The next two paragraphs should then be read by the class.

The teacher may use the same approach with the section about the mountain lion, wolves, deer, and a forest. Before reading the remainder of this first section, ask the children to indicate ways that they may use in discovering how living things help and harm each other. Reading, observing, and studying are suggested in the text.

At this point in the lesson, the teacher should plan with the children ways to learn the material in the unit. They will suggest sources for additional reading, places to go to observe, ways to obtain specimens for observation, etc. The teacher is urged to make as much use as possible of materials available in the community, such as: greenhouse, school garden, vacant lots, parks, apiary, zoos, and similar sources. It might be very interesting to ask each pupil to suggest one source where he thinks the class could find valuable information. This might be done after the class has looked ahead through the unit, looked at the pictures, and read the problem titles. This, by the way, is often a good way to create interest and at the same time let the children know more about where the unit will lead. If a field trip is arranged, this preview of the unit will be helpful in knowing what to observe.

The observations for this unit can best be made on a field trip. If it is possible to take a field trip with the class, it is advisable to do so, provided the pupils know what they are looking for. Look through the unit at the various problems. The aim of the trip should be to collect data to solve these problems. Each pupil should be expected to observe carefully enough to report findings to the class. It is important that you do not plan to observe too many things on one field trip. (Also see page 14 of the *Guidebook*.)

Children should be encouraged to take field trips by themselves after school or on Saturdays and report their findings to the class. Urge them to observe carefully so that their information will be accurate. Careful observation is one of the scientific attitudes that the pupils should acquire. They should be led to see that evidence based on one observation should be regarded as tentative, and other observations should be made to verify it.

How do animals help each other? (Pages 13-18)

Concepts

1. Some kinds of animals, called social animals, live and work together in a colony.
2. Some animals, such as ants and aphids, are mutually helpful.
3. Some animals grow up in families.
4. Some animals join together in groups for hunting and for protection.
5. Some animals are food for other animals.

Information for the teacher

PICTURES. PAGE 17. Aphids or plant lice are also black.

Page 18. Prairie dogs are not dogs but rodents. They are a kind of ground squirrel. They get their name from the barking sound that they make. Their colonies may cover a few acres or many miles in the Great Plains region, from Texas north through Montana.

Text. The children will be much more interested in studying about bees and ants if they have an opportunity to observe them. Pupils may be able to bring honeycombs and other material from a beehive. It is always interesting to keep an observation beehive in the classroom for a few weeks. Information about such a hive may be obtained by writing the General Biological Supply House, 761-763 E. 69th Place, Chicago 37, Illinois. The Bibliography on page 85 of the *Guidebook* suggests books about bees and ants which pupils can read. The *National Geographic Magazine* for April 1935 gives pictures and information about bees. See pages 90-91 of the *Guidebook* for directions for making a simple ant colony.

Procedure

The discussion about bees may center around these questions: "What work does each of the kinds of bees do in a hive?" "Why can a honeybee not live alone?" "In what very important way is a bee colony different from a community of people?" Have the children read pages 13, 14, and down to the last paragraph on page 15.

The section on ants and aphids may center around: "What things are probably happening in the two pictures on pages 16 and 17?" To answer this question, pupils must read from the last paragraph on page 15 to the end of the first complete paragraph on page 17. As a summary, pupils may then compare life in an ant colony with life in a bee colony.

Have pupils read the remaining paragraphs in this problem and then discuss: "What are some of the important advantages animals have when they live together?"

For additional activities, see *Things to Do*, Nos. 3, 8, 9, and 16.

Questions (Page 18)

1. Because they live and work together in a colony. Examples: bees, ants, beavers, prairie dogs.
2. Ducks, geese, and other birds fly together for protection; ants live together and help each other by each doing a certain part of the work of the colony; robins and other birds stay with their young until they are independent; wolves hunt in packs and attack together; beavers work together; prairie dogs live in villages and help each other by watching for enemies.
3. Men and women plan the work in a community while animals cannot think and do not know that they are helping each other.

How do plants help animals? (Pages 19-20)

Concept

Plants help animals by providing food and shelter.

Information for the teacher

Picture. Page 20. This is a flicker, or yellowhammer, a kind of woodpecker. It makes cavities in dead trees or branches for its nest.

Procedure

Before beginning this problem, ask the pupils to list as many ways as they can in which plants help animals. Their suggestions may come from observations made on field trips, from their own experiences, or from looking at the two pictures in this problem. After they have listed their suggestions, have them read pages 19-20 to find additional ideas.

Questions (Page 20)

1. Used by animals for food, for nests, and other kinds of shelter and protection.
2. Answers might include: squirrels eating nuts; woodpecker making hole in tree for nest; rabbit hiding in the grass; cows eating grass; beavers building houses from branches and small logs.

3. Animals such as cows and sheep depend mainly on grass for food. We depend upon these animals for part of our food and clothing.

How do animals help plants? (Pages 21-23)

Concepts

1. Bees and other insects carry pollen from one flower to another.
2. Birds eat destructive insects.
3. Earthworms cultivate the soil.
4. Animals scatter seeds.

Information for the teacher

Pictures. Page 22. The earthworm is also known as the angleworm and as the night-crawler. It comes up out of its hole at night when the ground is moist or damp.

Text. When pollen is carried from the stamen of one flower to the pistil of another flower, we say that the flower has been cross-pollinated. When this transfer is within one flower, the flower is said to be self-pollinated. Usually cross-pollination produces better seeds than self-pollination.

When a bee crawls around in a flower, pollen sticks to its hairy legs and to the hairs on its body, as shown in the picture on page 21. Usually the pollen is brushed into pollen "baskets" before it is carried to the hive. These baskets are special structures on the hind legs. Hummingbirds also carry pollen.

Procedure

The pictures on page 21 show one of the most important partnerships that animals and plants have. Ask the pupils if they can think what a bee gets from this partnership and what the flower receives and what they themselves get. After they have discussed the problem briefly, have them read the text to the end of the paragraph at the top of page 22 to check their ideas.

Suggest that the pupils look at the picture on page 37 (red-headed woodpecker) and tell another way in which animals help plants. The next paragraph on page 22 describes this way.

The earthworm (pictured on page 22) is the next example of how animals help plants. If possible, earthworms should be brought to class and observed. The discussion may center around this question: "How do earthworms help you besides being useful as fish bait?"

The remainder of the problem answers the question: "How have you helped seeds of plants get from one place to another?" Children may tell their own experiences.

Questions (Page 23)

1. Bees get nectar and pollen from the flowers, and the flowers get pollen for seeds from the bees.
2. Insects. Birds.
3. Loosen the soil so that air and water can reach the roots of plants.
4. The seeds are carried from one place to another by wind, insects, other animals, and people.
5. Bees and other insects carry pollen; birds eat insects; earthworms and moles loosen soil; furry animals scatter seeds by carrying them in their fur.

How do plants help each other? (Pages 24-26)

Concepts

1. Some plants furnish food or water for other plants.
2. Some plants furnish shade and protection for other plants.
3. Some plants climb on others to reach sunlight.
4. Decayed plants enrich the soil and thus help other plants.

Information for the teacher

Pictures. Page 24. *Left.* This fungus is the elm pleurotus, *Pleurotus ulmarius.* (In the *Guidebook,* some scientific names are used. They are included only to help the teacher look up further information if desired, since common names frequently vary.)

Right. Mistletoe grows on various deciduous trees (trees that lose their leaves) from New Jersey and Pennsylvania to Florida and New Mexico and inland in the Mississippi basin to Missouri, southern Indiana, and central Ohio. Birds eat the sticky berries and spread the seeds when they wipe off their bills on the branches of trees.

PAGE 25. *Left.* Jack-in-the-pulpit, also called Indian Turnip, is found throughout the country in rich woods. It blossoms in May. Later, the stalk with a cluster of red berries may be found.

TEXT. Descriptions and pictures of puffballs will be found in any of the popular books on mushrooms. The term *mushroom* is a general one that is commonly used to include all the fleshy fungi. Sometimes, however, it refers only to the umbrella or cap types. See the Bibliography on page 85 of the *Guidebook* for references on mushrooms.

Procedure

Since this unit deals with the living things in the children's environment, it is especially important that they do as much first-hand observing as possible. As has been previously suggested, field trips may be used to great advantage in teaching any of these problems. For example, in a ten-minute walk near the average school, pupils can observe many examples of how plants help each other. After this brief opportunity for observing, the pupils may return to the classroom, list the examples they have seen, and then read this problem to discover additional examples and add them to the list. A brief discussion of how each of the pictures on pages 24 and 25 shows the relationship of plants to each other should follow the reading of the problem.

Questions (Page 26)

1. A fungus is a plant (without seeds) that does not make its own food but grows on other plants or animals, or on soil that has decayed plants in it. Examples: mushrooms, puffballs.
2. Grass is a green plant that makes its own food from materials in the soil and air. A fungus must take food made by other plants.
3. Mistletoe cannot take its water directly from the soil. It must grow on other plants to use the water taken in by them.
4. Furnish support on which other plants climb toward the light.
5. There is more shade in the forest. Plants that require shade grow in the forest, and plants that require sun grow in open fields.
6. By decaying when they die and enriching the soil.
7. Furnish food or water for others; furnish shade and protection for others; provide support for others to reach the sunlight; enrich the soil when they die and decay.

How do plants harm other living things? (Pages 26-29)

Concepts

1. Some plants are poisonous to animals.
2. Plants such as fungi destroy other plants.
3. Some plants capture animals for food.
4. Some kinds of plants (bacteria) cause disease in other plants and in animals.
5. Stronger plants take water, food materials, and sunlight from weaker ones.

Observation

PAGE 28: To observe some mold.

MATERIALS: Piece of bread, dish to cover it, warm place to keep bread for several days.

Information for the teacher

PICTURES. PAGE 27. Venus's-flytrap is found in sandy bogs or peat bogs along the coast in North and South Carolina. The pitcher plant also grows in peat bogs. It is found in the north and south as far west as Minnesota.

PAGE 28. *Left*, corn smut; *center*, apple rust, which has its alternate stage on the common red cedar; *right*, plum dried by brown rot.

Text. On the field trip in the fall, the leaves of the poison ivy may have turned red. In some parts of the country, the vine form is common and often covers stone walls, fences, and tree trunks.

An excellent bulletin describing the different types of poison ivy is *Poison-Ivy, Poison Oak, and Poison Sumac*, Farmer's Bulletin No. 1972, U. S. Dept. of Agriculture, Washington, D. C., August 1945.

Life for June 14, 1943, has some exceptionally fine photographs of insectivorous plants. These plants are also called carnivorous plants since they are "meat eaters."

Both the ordinary bread mold (Rhizopus) and the blue-green mold (Penicillium), usually found on fruit and other foods, may appear on the bread.

Procedure

Before the pupils study this problem, have them discuss these problems: "How have plants ever harmed us?" "How do plants harm other plants?" "How do they harm animals?" After the discussion, pupils should read the text to answer the questions. Then they should discuss the questions again. It is especially important that the paragraphs on poison ivy be given careful attention. If it is not possible to show poison ivy in the field, the following method may be used to exhibit it safely in the classroom: Hold a wide-mouthed gallon jar (or similar glass jar with a screw top) over a branch of ivy. Clip the stem at the mouth of the jar and screw the cap on. Do not let leaves from the plant brush the outside of the jar. A branch will last a week or ten days when exhibited in this way. Be careful not to touch the branch while disposing of it since it may still be poisonous.

After the discussion and after the questions on page 29 have been answered, the children may tell what each picture in this problem illustrates about how plants harm other living things.

Questions (Page 29)

1. By taking away its food, sunlight, and water.
2. Weeds take the sunlight, food materials, and water that our garden plants need.
3. Some will take food, water, and sunlight from the others.
4. Fungi harm other plants by taking their food. Fungi cause diseases in other plants. Plants take food, water, and light from other plants.
5. So that others may get the sunlight, food, and water that they need to become strong and usable.
6. Are not green plants. Do not make their own food but live off other growing or dead plants; are often harmful to growing plants; may cause diseases in plants and animals.
7. Answers may include: thorns scratch and tear animals (deer in brambles); some are poisonous to animals (cow eating snakeroot); bacteria cause diseases in animals (tuberculosis in cows).

How do animals harm other living things? (Pages 30-32)

Concepts

1. Animals use either plants or other animals for food.
2. Insects are great enemies of plants and animals.

Information for the teacher

Pictures. Page 30. *Top.* Besides birds, a weasel eats many of the smaller mammals, some of which are many times the size of the weasel. It is a bloodthirsty little animal and often seems to kill for the sake of killing as well as to obtain food. *Center.* This is a cornfield that has been visited by a swarm of grasshoppers. In years when there are many grasshoppers, they frequently descend on corn or wheat fields and leave them completely leafless. *Bottom.* This is an example of an insect that is parasitic on another insect. The caterpillar is covered with the cocoons of another insect. A fly laid her eggs on the caterpillar. The larvae hatched from the eggs, fed on the caterpillar, and then attached their cocoons to it. The caterpillar will, of course, soon die.

Page 31. *Top*, the larva of the codling moth. The moth lays its eggs on the leaves of the apple trees. When the larvae hatch, they crawl into the young fruit and feed until they are fully grown. Then they leave the apple and spin a cocoon. *Center*, the Mexican bean beetle. This is one of the few members of the ladybird beetle group that is injurious. Most of them are beneficial since they feed on other harmful insects. But both the larvae and adults of the Mexican bean beetle cause great damage to bean crops by feeding on the leaves of the bean plants. *Bottom*, the larva of the European corn borer. This is one of the most destructive insects. It bores into almost any part of the corn plant, destroying it by causing the stem to break or by making the ear useless, as in this picture.

Page 32. *Left*, the tunnels made by the bark beetle. The female beetle makes a tunnel in which she lays her eggs. When the larvae hatch, they make additional tunnels. This does great damage to the wood and bark and causes losses running into millions of dollars each year. One species attacks pines exclusively, but others attack almost every kind of tree. *Center and right*, cotton boll weevil. The center picture shows the beetles on the outside of the cotton boll. The right-hand picture shows the larvae inside a boll that they have destroyed.

Procedure

In preparation for this problem, the teacher may suggest that the pupils do one or more of the following: bring to class a picture that shows how animals harm other living things; report an observation they have made of an animal harming another living thing; or bring to school an example of a living thing that has been harmed by another living thing.

Before children study this problem, give them opportunity to show the pictures or samples they have brought to class or to tell about the observations they have made. Then ask the pupils to tell what they think the pictures on pages 30, 31, and 32 show. Ask them how they think the things shown in the pictures affect their lives.

After this discussion, the pupils are ready to read these pages carefully to add to the knowledge that they have gained and to check their observations. See also *Things to Do*, page 43, Nos. 11 and 13.

Questions (Page 32)

1. To get food.

2. Answers may include: cats catching mice or birds; fish eating flies or worms; frogs eating insects; flies biting horses; spiders eating insects.

3. Answers may include: rabbits eating leaves and vegetables; cows and sheep eating grass; worms eating apples; birds eating cherries; beavers gnawing trees; beetles or caterpillars eating leaves; woodpeckers pecking trees.

4. People can find out the best time to try to kill them. People can kill them before they can have young like themselves.

5. Eating the leaves; eating the fruit; sucking the sap.

How do plants help us? (Pages 33-35)

Concepts

1. All of our food comes directly or indirectly from plants.

2. We use plants for clothing, wood, rubber, medicines, etc.

3. Plants hold the soil in place and thus help prevent floods and dust storms.

Information for the teacher

Pictures. Page 33. *Left*. The method of tapping trees for turpentine shown in the picture is one that has been commonly used and is still widely seen. However, this kind of cutting is injurious to the tree and causes many to die. Newer methods are coming into use, in which just a narrow cut is made and the resin conducted through a narrow metal trough to a cup that hangs on a nail below the open surface. The yield has been found to be as good as with the old way, and the number of trees killed by the operation has been greatly reduced. Pine trees tapped for turpentine in one or the other of these ways are a familiar sight in Georgia, northern Florida, and the other Gulf states.

Right. This picture shows the harvesting of a field of hemp to be used for making rope. This machine is a hemp gatherer-binder. Before final harvesting, the hemp is allowed to remain in the field for two to six weeks for retting, or the beginning of rotting. This is the first step in the process of obtaining the fibers from the hemp stalks. The fibers are later used for rope.

PAGES 34-35. These two pictures show one way in which bare, eroded hillsides can be reclaimed.

TEXT. Other medicines that come from plants are: camphor (from camphor tree), morphine (from opium poppy), quinine (from bark of cinchona tree), licorice (from licorice root), senna (leaves of several species of Cassia and other leguminous plants), belladonna (from roots and leaves of deadly nightshade), digitalis (from foxglove).

The important drug penicillin comes from the same kind of blue-green mold, Penicillium, found growing on bread or fruit. The species usually used to obtain the drug is *Penicillium notatum*. Streptomycin is made from another microscopic plant found in the soil.

See the Bibliography on page 85 for suggested books and pamphlets that will furnish additional pictures and information on the use of plants in holding the soil.

Many common objects are now made from plastics derived from plants. Soybeans, corncobs, wood pulp, cotton linters, and other plant sources of cellulose are used.

Procedure

Pupils will already have considerable background of information about this problem on how plants help us. The class may be divided into three groups and given ten minutes to make a list of as many ways as they can in which plants help. One group may list the things that they can see in the schoolroom; another, the things that they can see from the window; and another, things found at home.

Many schoolyards have examples of erosion that show up after a sudden shower. Ask the children whether they know of such a place and have them go to observe it after the next rain. For another activity to show how plants help hold the soil: Put about equal amounts of dry soil and dry sod on pieces of board. Put the boards outside on a windy day or turn a fan on them. Which board is blown clean first? What does this show? Have the pupils read the text, look at the pictures, and discuss what they have learned. See also *Things to Do*, page 43, No. 5.

•

Questions (Page 35)

1. Pupils may answer: wheat (flour, bread); potatoes, corn, beans, carrots, lettuce, etc., depending on location and season.
2. Cotton, flax (linen), hemp (carpets), straw (hats).
3. Leaves and branches provide a spongy covering that catches the water and prevents it from washing the soil away. The roots of plants keep the soil from washing away, too. Plants help prevent dust storms when their roots form a network that holds soil or when their leaves and stems slow the wind down.
4. By making a covering for it and holding it with their roots.

How do animals help us? (Pages 36-37)

Concepts

1. Food, clothing, and other products come from animals.

2. Some animals protect us or do work for us.

3. Some animals destroy plant and animal pests.

Information for the teacher

Pictures. Page 36. Sheep dogs are an important part of every sheep raiser's equipment. Some of the breeds used in this work are: Old English sheep dog, collie, Shetland sheep dog, German shepherd dog.

Page 37. Red-headed woodpecker. Much of this woodpecker's food consists of harmful insects such as scales, weevils, cicadas, and others. It can catch insects on the wing as well as dig for them in trees.

Procedure

The same procedure as suggested for the previous problem on plants may be followed for this problem on animals. Have pupils collect pictures that show how animals help us and make a bulletin board display of them.

Questions (Page 37)

1-2. (*a*) Sheep, cows, pigs, chickens, turkeys, fish, rabbits, etc., supply meat. Cows and goats supply milk. Chickens supply eggs.

b) Skins of horses, cattle, pigs, sheep, and reptiles are used for leather; sheep supply wool; silkworms supply silk.

c) Horses, dogs, oxen, camels, and llamas are used to pull loads and carry burdens.

d) Dogs are used to guard property; cats kill mice and rats; birds protect crops by eating pests; skunks and snakes also eat pests.

e) Hawks and owls eat rats, mice, and other pests; cats, skunks, and snakes destroy mice.

How do we conserve the living things that help us? (Pages 38-41)

Concepts

1. We raise and take care of plants and animals on farms.

2. *Conservation* means the protection and wise use of wild life, forests, soil, and other things.

Information for the teacher

Pictures. Page 38. This Georgia boy is raising slash pine as his 4-H Club conservation project. On a one-acre project, he has 1000 trees. (See Ross L. Holman, "Youth, Trees and Game," *American Forests*, June 1942.)

Page 40. The Department of Conservation in your state will furnish a list of the wild flowers and other wild life that should be protected or that are protected by law. This pink lady's-slipper is also called moccasin flower. It has disappeared from many localities because of careless picking. It has only two leaves. If these are picked, the plant cannot store food for another year.

Text. Much material on conservation is available. Consult the Bibliography on page 85 for references on conservation. Obtain material from your own State Department of Conservation. In this way, the conservation teaching can be keyed to local needs and conditions.

Procedure

This problem is one of the most important in the entire unit. Every effort should be made to make it as real as possible to the pupils. If possible, obtain a motion picture from your State Department of Conservation and take a field trip to see a conservation project. Emphasize repeatedly what pupils themselves can do to help conserve living things. Refer to the picture on page 38 as an example of what boys and girls can do. The discussion of this problem may center around these questions: "Why is it important that we conserve our wild plants and animals?" "What is being done in our county to conserve our living things?" "How can pupils in our class prevent wasteful use or destruction of living things?" After discussing these questions, have the pupils read the problem for additional information. See also *Things to Do*, pages 42-43, Nos. 2, 7, 10, 12, 14, 15, and 17.

Questions (Page 41)

1. *Conservation* means protecting something or using it wisely.

2. Replanting forests; protecting young trees; protecting forests from fire; killing insects that damage and destroy trees.

3. By not cutting down or damaging trees; using caution in making and leaving campfires and in using any fire in the woods.

4. Passing laws against killing them and restricting the hunting of wild animals; providing homes.

5. Thoughtless destruction of plants and animals and their homes. Obey the laws controlling their conservation; provide food and homes for animals.

Questions to answer (Page 42)

1. To discover whether the animal is helpful or harmful to us.

2. Furnish food for each other.

3. Animals are dependent on plant life for food, but plants can exist without animals.

4. People can think and plan.

5. To make sure that each plant will have the needed amount of water and sunlight; so that weeds can be removed and the soil loosened with machinery without disturbing the plants.

6. Not enough sunlight.

7. Animals such as birds, deer, bears, otters, beavers, and other animals. Plants such as lady's-slipper, trillium, gentian, etc. (Answers will depend on the conditions in each state or region. In Florida, for example, the sea cow or manatee is one animal that should be protected.)

Things to do (Pages 42-43)

1. All destroy harmful insects. Skunks and snakes destroy mice. (See Bibliography on page 85.)

2. A visit to a hatchery, if possible, would help to concrete children's ideas.

3. See Bibliography on page 85.

4. Use text, observations, and additional reading.

5. Pictures may be made into scrapbooks with information written about each one.

6. Can be a talk to the whole group or an individual assignment.

7. Use the text and additional reading on forest conservation.

8. See Bibliography on page 85.

9. Find examples from observation and reading. Reports may be made orally, and the best ones used for scrapbooks.

10. The following will give help in building birdhouses.

House Plans—Circular No. 29. This little leaflet contains plans and directions for making bird boxes, and directions for placement. National Audubon Society, 1000 Fifth Ave., New York 28, N. Y.

Songbird Sanctuaries by Roger T. Peterson. Tables of trees, shrubs, and vines attractive to birds. 32 pp. National Audubon Society.

The National Audubon Society also has various types of birdhouses and feeders for different places and different birds.

Wings at My Window by Ada C. Govan. Macmillan, N.Y., 1940. 198 pp. A simple account of an ordinary American family's experiences with birds about their home grounds.

11. See the text, pages 30-32, for examples of the kinds of things the pupils may find, depending on the season and the region. They may also bring in plants with galls, or swollen, tumorlike growths caused by insect injury. If these are cut open, many of them will be found to harbor the insects that caused them.

12 and 14. Class activity.

13. The Panama Canal was first attempted by the French, but the workers were attacked by yellow fever. After thousands died, the work was abandoned. Later, it was discovered that the fever is carried by a silver-striped mosquito and contracted only through its bite. The United States made a successful campaign against this mosquito, with particular effort directed toward elimination of mosquito breeding places, and was able to complete the

Canal. See *Men Who Found Out*, by Amabel Williams-Ellis (Coward-McCann, Inc.), or an extract from it, "Fighting Yellow Fever," in *Literature and Life, Book Two, Revised* (Scott, Foresman); or refer to *mosquito, Panama Canal, William Crawford Gorgas*, and *Walter Reed* in an encyclopedia.

15. May be found in nature magazines, outdoor magazines, or newspapers. The National Wildlife Federation, 1129 Vermont Ave. N.W., Washington 5, D.C., has postcards or stamps showing the flowers that need special protection. Material issued by either national or state government departments of conservation may be helpful.

16. See Bibliography on page 85 or any of the children's encyclopedias.

17. Class or individual activity.

UNIT 2. *What Makes Things Move?*

Purpose and scope

Through a study of this unit, the pupils learn fundamental ideas upon which they will build when they study energy and work later in their science course. It introduces them to the world of forces. The unit is full of examples of how we use the energy of the world to do our work. The examples are those which children encounter every day. Pupils should be encouraged to observe these examples, become conscious of how they operate, and appreciate the importance of them. It is not necessary that the children learn the names of the different kinds of energy at this grade level.

Science background

Look and Learn: Unit 2, Machines

All Around Us: Unit 2, Getting Work Done

How Do We Know?: Unit 4, Wheels and Levers

Discovering Our World, Book One: Unit 2, Why Do All Living Things Need Air and Water? Unit 3, How Does Your Body Work? Unit 6, What Can Magnets Do?

General concepts

1. Things move because they are pulled or pushed by some force.
2. Force is produced by energy.
3. There are different forms of energy.
4. Muscles have energy.
5. Springs have energy.
6. Gravity is the force that holds things to the earth.
7. Moving water has force.
8. Air has force when it moves.
9. Steam has force.
10. Gasoline and oil have force when they change to a gas and explode.
11. Electric current has energy that makes a force which can move things.
12. One form of energy can be changed into another form of energy.

Introducing the unit (Page 45)

Information for the teacher

PICTURE. PAGE 44. This is Yosemite Falls, in Yosemite National Park, California.

Procedure

The pictures in the unit each show something that moves. Pupils may make a list of the things that the pictures show and after each example try to tell what makes it move. This activity will provoke discussion and raise many of the problems with which the unit deals. The introductory section may be read after the class has made a list by using the pictures.

An interesting activity to accompany the study of each of the problems is this: Suggest that each pupil try to observe during his out-of-school time examples of places where things are being moved. Pupils will then report their observations to the class.

The problem on the force of moving water will be more interesting and real if a water wheel like the one described on page 54 is available or can be made. Discuss this idea with pupils and ask for volunteers to have one ready to demonstrate before the class.

Why do things move? (Pages 45-48)

Concepts

1. Things move because they are pulled or pushed by some force.
2. Force is produced by energy.
3. There are different forms of energy.

Information for the teacher

PICTURES. PAGE 47. *Top.* This is a DC3, or Douglas transport. *Bottom.* This picture was taken when water filling Lake Mead, the 115-mile reservoir back of Hoover Dam (formerly Boulder Dam), took its first spill into the concrete trough on the Arizona side, to be carried through great tunnels around the dam. The water flowing through these tunnels is used for irrigation.

TEXT. There are two main kinds of energy: *kinetic energy* and *potential energy.* Kinetic energy is the energy that things have because they are moving, that is, the energy of motion. Wind, rushing water, a moving automobile, etc., all have kinetic energy. Potential energy is the energy stored in matter. It may have this potential energy (1) because of its position, such as something up high; (2) because of its condition, such as the wound-up spring of a watch or the stretched spring of a door; or (3) because of its chemical composition, such as fuels, foods, and explosives.

There are different forms of kinetic and potential energy: mechanical energy, chemical energy, heat energy, light and other forms of radiant energy, sound energy, and the energy of magnetism. Some of these forms of energy, such as mechanical energy, may be potential at some times and kinetic at others. Chemical energy is always potential energy, because it is stored in materials. Heat is always kinetic energy, since it is actually the motion of molecules in materials.

Procedure

In teaching this first problem, keep in mind the concepts that you are trying to help the children understand. (See the list above.) This understanding comes about through discussion of the many examples listed in the section.

The teacher may begin this section by lifting a chair up on to a table and asking the children this question: "When I lift this chair, will you observe very carefully what happens and then tell what you see?" (The chair is moved. It was pulled and pushed. The force of muscles moved it.) After the pupils have given their observations, ask them to read the paragraph at the bottom of page 45.

Ask the children to select the sentences that they think tell the most important ideas and write these two sentences on the board for future reference: "Nothing moves unless something pulls or pushes it." "Whenever anything in the world moves, it is moved by some force."

Ask the class to read the paragraph at the top of page 46. Have them list the things that are moved. Then the pupils should read the next paragraph and list opposite each moving thing the force that moves it. Then have the pupils read the next paragraph to find another important idea to list on the board: "Without energy, there would be no force."

The next paragraphs tell what energy means. Let the pupils read the rest of the problem and again find important ideas to list: energy is the ability to do work; energy makes force possible; there are different forms of energy; every force is supplied by some form of energy. Also see *Things to Do,* page 69, No. 6.

Questions (Page 48)

1. A pull or a push. Force of wind, water, steam, electric current, gasoline, muscles.

2. Energy is the ability to do work. We know something has energy when it can make a force that moves something.

3. All of them. They can all make something else move.

4. From the energy of the muscles of the person who threw, kicked, or hit the ball.

5. Nothing would move.

Where do your muscles get their energy? (Pages 48-49)

Concepts

1. Muscles get their energy from the food that is eaten.
2. Food has energy stored in it.

Information for the teacher

PICTURE. PAGE 49. The energy of muscles (the dogs' and the man's) is being used. The energy has come from the food that the man and the dogs have eaten.

TEXT. The energy stored in food is chemical potential energy. It is potential energy because it can do work only after it has been changed into kinetic energy, or the energy of motion. It is chemical energy because a chemical change is necessary to change the energy from potential to kinetic energy.

Procedure

In introducing this problem, ask the pupils what they have already learned about this question: "How do your muscles get their energy?" After this discussion, the problem may be read by the class. Pupils may discuss the question: "How would the world be different if we had never learned to use any energy except the energy of muscles?"

Questions (Page 49)

1. From the food that we eat.
2. From the food that they eat.
3. Yes. Our breakfast is changed in our bodies into the energy of muscles, which we use in riding a bicycle.

How do springs get their energy? (Page 50)

Concepts

1. Springs get energy when they are wound up.
2. Springs get energy when they are pushed in or pulled out.

Procedure

In preparation for this problem, ask the pupils to bring to class something that works by using a spring. Let them show the things they have brought and have them show how the spring makes them work. Then ask others to suggest additional things that they have seen which operate by using springs. The problem may then be read and discussed.

Questions (Page 50)

1. Answers may include springs on screen doors, toys, curtain rollers, bird cages, etc.
2. Giving it the energy of your muscles, which it uses when it unwinds, pulls back, or pushes out.

What is the greatest force in the world? (Pages 51-52)

Concepts

1. Gravity is the force that holds things to the earth.
2. Gravity pulls things from higher places to lower places on the earth.
3. The pull of gravity gives things weight.

Information for the teacher

PICTURE. PAGE 51. Gravity is pulling the children downhill.

Procedure

The picture on page 51 may be used to introduce this problem by asking the class to answer the question above the picture. After pupils have discovered that this force is gravity, ask some of the pupils how much they think gravity pulls on them. (It is the amount of their weight as shown by a scale.) Following this discussion, the pupils are ready to read the problem to find out why gravity is the greatest force in the world.

Questions (Page 52)

1. Everything in the schoolroom.
2. Feather, rock, pail of water. (Noise and sunshine are forms of energy.)
3. Gravity pulls on it.
4. How much gravity is pulling on you.
5. (*b*) and (*d*).

How do we use moving water? (Pages 53-55)

Concepts

1. Moving water has force.
2. The faster the water moves, the more force it has.
3. The force of gravity makes water run from high places to lower places.
4. Dams are built to raise water to a higher level so that it can fall and thus provide greater force.

Experiments

PAGE 54: To make a water wheel and show how it works.

MATERIALS: Two thin boards, six small nails, three narrow pieces of wood, saw, hammer, running water.

PAGE 54: To show how a water wheel is used to turn another wheel.

MATERIALS: Water wheel made above and toy Ferris wheel (or some other toy that can be turned in this way), spool, small nails, string.

Information for the teacher

PICTURES. PAGE 53. Flood damage along the Connecticut River at Hadley, Massachusetts.

PAGE 54. *Top*, an undershot water wheel. This means that the water turns the wheel by striking the paddles as it flows under the wheel. In an overshot water wheel, such as the one in the picture on page 69, the water turns the wheel by striking the paddles as it flows over the wheel and falls.

PAGE 55. *Left*. This is the Rock Island Dam on the Columbia River, near Wenatchee, Washington. At the right end is the building that houses the water wheels, or turbines. At the left is the spillway that allows excess water to flow out of the reservoir so that water will not flow over the top of the dam.

TEXT. Some of the great water-power plants in the United States are: Niagara Falls, New York; Hoover Dam, Arizona-Nevada; Conowingo, Maryland; Keokuk, Iowa; Bonneville, Oregon; Grand Coulee, Washington; Wilson Dam, Tennessee River.

Dams vary somewhat in construction, depending on the primary purpose for which they are made and the location of the dam. Dams to be used primarily for flood control and irrigation may be different from those that are to be used primarily as sources of water power.

Procedure

Introduce this problem by letting the pupils who constructed the water wheel show it to the class and operate it. Let them run it fast and slow and suggest that the children observe it closely. Leave the water wheel where the pupils who are interested can operate and observe it. After this experience, the pupils are ready to study the pictures and read the text of this problem. The picture at the right on page 55 gives a simple explanation of how a dam operates to turn a water wheel. If possible, a field trip to a dam to observe this action will be profitable and interesting. It is not intended that pupils at this level go into the mechanics of how the wheel makes electric current.

Questions (Page 55)

1. The water wheel in the stream flowing down a mountain, because the water is moving faster and exerts more force on the wheel.

2. So they could make use of the force of moving water to run machines.

3. Yes. Without energy, moving water would have no force.

4. Water wheels are turned by the force of moving water, which is being pulled downhill by gravity.

How do we use moving air? (Pages 56-58)

Concepts

1. Moving air has force.
2. The faster air moves, the more force it has.
3. The force of gravity makes air move.
4. People have learned how to make air move to provide force.

Information for the teacher

In a vacuum cleaner, the fan is part of a centrifugal air pump driven by the motor. As the fan turns rapidly around, a partial vacuum is created near the center of the pump. Atmospheric pressure forces more air in through the nozzle of the cleaner and into the center of the pump. When the cleaner is pushed across a rug, the air rushes through the rug and into the cleaner, carrying dirt and dust with it.

Procedure

In preparation for this problem, it may be possible for some pupil to bring a sailboat to class and for someone to bring a vacuum cleaner. After experiences with the sailboat and vacuum cleaner, the pupils may make a list of places where they have seen the force of moving air in use. Then they may study this problem, look at the pictures, and add to the list. Some of the children may want to make and use pinwheels, as suggested on page 57.

Questions (Page 58)

1. In all of the ways listed.
2. One run by an engine. You cannot be sure that the wind will blow when you need it.
3. An electric motor runs a fan, and the fan makes the air move into the cleaner.
4. In windmills, sailboats, iceboats.

Why can steam move things? (Pages 59-61)

Concepts

1. Steam has force because water takes up more space when it changes to steam.
2. The energy that a steam engine uses comes from coal, oil, or other fuel.
3. Every steam engine must have heat and water.

Experiment

Page 60: To show that steam has force.

Materials: Test tube, cork, test-tube holder, source of heat.

Information for the teacher

Pictures. Page 59. This is a mountain-type locomotive.

Page 60. The inside of a mountain-type locomotive. The water in the boiler surrounds a great number of tubes. The fire and the hot gases from it pass through the tubes and heat the water. The pipe that carries the steam to the cylinders and pistons that move the wheels is in the space above the water. Steam enters and follows the path marked by the arrows.

Page 61. A De Laval turbine. This kind of wheel turned by steam was invented by a Swedish inventor, Carl De Laval, for use in cream separators. This principle is used in the large steam turbines that have many blades. Note that the steam is not visible. The white cloud consists of water droplets formed when the steam coming out of the tube condenses as it reaches the cooler air.

Procedure

Do the experiment suggested on page 60 and ask the pupils to explain what happens. Then have them examine the diagram on page 60 to see whether they can explain how steam makes the locomotive go. After the experiment and discussion, the pupils should read pages 59-61 to discover additional ideas. See also *Things to Do*, page 69, Nos. 4 and 8.

Questions (Page 61)

1. A boiler for water and a fire to change the water to steam.
2. Heat. When water boils, it changes to a gas, steam.
3. Gas. No. It is colorless. What you see is a cloud of water droplets formed when steam condenses as it cools.
4. Steam has force. The energy of the expanding steam makes the force. The steam takes up much more space than the water and so pushes against the cork.
5. The steam is sent to the part of an engine that turns a wheel. It pushes hard to get out. In doing this, it turns the wheel.

How do we use the force of explosions? (Pages 62-63)

Concepts

1. When anything explodes, it suddenly gets very much larger.
2. Gasoline and oil have force when they change to a gas and explode.

Information for the teacher

The parts of a gasoline engine where the explosions occur are the cylinders. The force of the expanding gas pushes down on the pistons, which are attached to the drive shaft that turns the wheels. If further details are desired, see a general science book or an elementary physics book for a description of how the gasoline engine works.

In a Diesel-driven locomotive such as the one on page 63, much of the space in the three or four units of the locomotive is occupied by the generators. The Diesel engine furnishes the energy to run the generators. The generators run motors, which turn the wheels. Thus, this is properly called a Diesel-electric locomotive.

Procedure

Have the children read pages 62-63. Pupils at this level are not expected to go into a technical discussion of the internal-combustion engine. It is sufficient for them to realize that the force of the exploding gas is responsible for moving a car or other machine. If the high-school shop has a cut-away model, the pupils may be interested in seeing it. See also *Things to Do*, page 69, No. 7.

Questions (Page 63)

1. (*a*) liquid; (*b*) gas; (*c*) force; (*d*) larger.
2. *Alike:* produce force by being changed from liquids to gases; get larger and push out. *Different:* Water does not explode to make steam; gasoline explodes to become larger.
3. An electric spark.

How does electric current move things? (Pages 64-66)

Concepts

1. Electric current has energy that makes a force which moves things.
2. An electric motor is a machine that uses the energy of electric current.
3. Electric current can be made in two ways.
   a) Electric current is made to flow by a generator that is run by some other force.
   b) Electric current is made to flow by an electric cell.

Experiments

PAGE 64: To show that electric current can make a magnet.

MATERIALS: Large iron nail, cotton-covered copper wire, dry cell, tacks.

PAGE 65: To find out how one magnet will turn another.

MATERIALS: Two bar magnets, wooden support, string.

PAGE 65: To show how electric current runs a motor.

MATERIALS: Two dry cells, cotton-covered copper wire, toy motor.

Information for the teacher

Electromagnets, kinds of electric cells, motors, etc., will be discussed in more detail in Unit 5 of *Discovering Our World, Book Three.* The cells shown in use in these experiments are dry cells. Do not leave the dry cells connected for too long, as they will wear out. There is no danger of the pupils getting a shock from the dry cells. But if there is a complete circuit for too long a time, the wires become heated enough to burn the fingers.

Procedure

If any pupil has an electric train and can bring it to school, have him operate the train for the class to observe. The pupils should do the experiments pictured at the bottom of page 64 and the ones on page 65. Then have them read the problem to check their findings. The technical explanation of how an electric motor operates is not to be considered. The important idea is that the energy of electric current is very useful. Have the pupils list as many places as they can where they have used the energy of electric current to move things.

Questions (Page 66)

1. With a generator; with an electric cell.
2. Because it produces a force that will turn a motor.
3. Washing machine, vacuum cleaner, streetcar, water pump, electric refrigerator, electric fan, etc.

How can one form of energy be changed to another? (Pages 67-68)

Concept

One form of energy can be changed into another form of energy.

Information for the teacher

Pictures. Pages 66-67. The electric current is sent from the generators through "high tension" wires supported by tall steel towers. From these wires, the current is stepped down, that is, the voltage is reduced, for ordinary use. It may be stepped down by transformers several times between the original source of the current and the place where it is finally used, depending on how much voltage is required.

The pictures show only two wires for the sake of simplicity. Actually, the current is usually carried by three wires, one of which is neutral or grounded.

Page 68. This wind generator was in use for several years near Rutland, Vermont. Larger generators of this type have been planned for use in other parts of the country.

Text. One form of energy can be changed into another just as matter can be changed from one state to another. The recent work on nuclear fission has also shown that, under certain conditions, energy can be changed into matter and matter into energy. This discovery has led many scientists to believe that the laws of conservation of energy and of conservation of matter are really two parts of the same principle. The sum total of energy and matter in the universe remains the same, although the amount of each may change as matter or energy changes from one to the other.

Procedure

Use the pictures on pages 66-67 as an introduction to the last problem of this unit. Let the pupils discuss how they think energy of moving water is keeping Betty cool. After this discussion, let the pupils read page 67 and then ask them to think of places where one form of energy is changed to another. After this discussion, have them read page 68.

In concluding this unit, the pupils may make a list of the important ideas that they have learned (see concepts) and try to find places where these ideas are functioning in their environment. This activity may be combined with *Things to Do*, Nos. 1 and 5, on page 69.

Questions (Page 68)

1. Gasoline engine could run a machine to generate electric current that would turn a fan.

2. Many electric generators are run by steam made by heating water with a coal fire. The electric current could run a fan.

Questions to answer (Page 68)

1. Electric current: heat, light, cooking, cleaning, ventilation, telephone.

2. All have energy and create force; they can move things; they are strong and can help or harm us.

3. Makes rivers move to make electric current, causes water to soak into the ground for plants, etc. Makes things hard to lift, makes it difficult for us to fly, etc.

4. Electric current because it can do so many things for us.

5. *Dentist:* electric current to run his drill, etc. *Farmer:* electric current, wind, water, etc., to run machines. *Railroad engineer:* steam, explosion of gasoline or oil, electric current to run trains. *Repair man:* electric current to run his tools, etc.

6. Explosion of gasoline (motor running threshing machine); muscles (men and horses); moving air (blower in thresher); wind (windmill).

Things to do (Page 69)

1-2. Individual activities.

3. May be steam or moving water.

4. Usually run by alcohol lamp or electric current.

5. Story on page 45 will be helpful in writing this story.

6. Lists will vary but might include moving a piano or other furniture, bricks or lumber for a house, load of hay, etc.

7. (*a*) Usually blasted loose with dynamite or TNT; (*b*) by force of the exploding gunpowder in the cartridge.

8. If possible, arrange for a visit to see a steam locomotive. The engineer will probably be willing to answer questions that the pupils ask.

UNIT 3. *How Is Our Work Made Easier?*

Purpose and scope

The purpose of the unit is to acquaint pupils with the importance of machines, to help them become aware of how they work, to teach them the easiest principles of how machines work, to impress them with the importance of safety rules in using machines, and to increase their interest in and appreciation of machines. It is important to remember that girls, too, are interested in this unit as well as the boys. Girls may be apt to assume that the material is difficult until they see how simple it really is. They will become more convinced of this as they begin to see how many of the things that they use every day are really machines. At this level, it is not necessary to go into the mathematical relationships involved in explaining how machines help us. It is sufficient to demonstrate that machines do.

Much of the success of this unit depends on giving pupils actual experiences that will make the science concepts real and understandable. Many simple machines will be found in the classroom (pens, pencils, pencil sharpener, window pulleys, etc.). If there is a general shop or an auto shop in connection with your school or a nearby school, it will furnish excellent examples of the ideas developed. The occupations of many of the fathers of the pupils will be useful as examples. The machines used in the kitchen and elsewhere in the home, those used in constructing buildings near the school and many other places will all be useful.

Science background

Look and Learn: Unit 2, Machines
All Around Us: Unit 2, Getting Work Done
How Do We Know?: Unit 4, Wheels and Levers
Discovering Our World, Book Two: Unit 2, What Makes Things Move?

General concepts

1. A machine is a device that makes work easier.
2. A force must be used to make a machine work.
3. Simple machines have only a few parts.
4. Machines with many parts are made up of simple machines put together in different ways.
5. Levers, inclined planes, pulleys, and wheels and axles are simple machines.
6. One wheel can be used to turn another wheel.
7. Machines can be made to work more easily when we reduce the friction in them.
8. Friction is often useful and is needed to help us do work.
9. Machines can be dangerous and must be used carefully.

Introducing the unit (Page 71)

Begin by asking pupils to suggest situations in which they have seen machines being used. List these for future use and suggest that the pupils observe them to find examples of the things they are studying. After the list is made, ask: "How many ways can you think of in which machines help us?" (To lift, to move, to cut, etc.) Pupils may then read page 71 to find out what is happening in the picture at the top of the page and to find some of the ways in which machines help us. After this reading and discussion, ask the pupils to examine the picture at the top of page 72 and answer the two questions asked under the picture. (See "Information for the teacher" on this page of the *Guidebook.*)

What is a machine? (Pages 72-73)

Concepts

1. A machine is a device that makes work easier.
2. A force must be used to make a machine work.
3. Simple machines have only a few parts.
4. Machines with many parts are made up of simple machines put together differently.

Experiment

PAGE 73: To show that a machine makes work easier.

MATERIALS: Orange, knife, orange squeezer, glass.

Information for the teacher

PICTURE. PAGE 72. *Top, left,* squeezing an orange—use an orange squeezer; *center,* breaking a stick of wood—use a saw or a hatchet; *top, right,* tearing a piece of cloth—use scissors; *bottom, left,* moving a heavy box—put it on something with wheels; *bottom, right,* getting heavy stone off the ground—use a lever.

TEXT. Background material on machines can be found in a general science book. Some books list six simple machines: lever, inclined plane, wedge, screw, pulley, wheel and axle. In this book, the wedge and screw are classed as inclined planes, since they are both made from inclined planes.

Procedure

This problem may be introduced by following the suggestion in the first paragraph on page 73. The orange squeezer makes the work easier. After this experience suggest that the pupils read the entire problem to find out: (1) How machines are different. (2) How they are alike. (3) What things they can do for us.

Questions (Page 73)

1. To make our work easier.
2. Answers may include hammers, saws, scissors, screwdrivers, etc.

How do we use levers? (Pages 73-77)

Concepts

1. All levers have three parts: the fulcrum, the part where the force is used, and the part where the work is done.
2. The nearer the fulcrum of a lever is to the weight, the easier it is to lift the weight.
3. A lever increases the force or changes the direction of the force.

Experiments

PAGES 74-75: To see how a lever works.

MATERIALS: Board three feet long and three inches wide, three-sided block of wood about two inches high, two small boxes of the same size, stones, sand or other weight, scales to weigh boxes.

PAGES 76-77: To see how levers make work easier.

MATERIALS: Hammer, tack, board, claw hammer or tack puller, large stone or weight, small stone, crowbar or strong wooden stick such as a broomstick (weight must be limited if a wooden stick is used).

Information for the teacher

PICTURES. PAGE 76. They are using levers to lift something up by pushing down. They are increasing the force and changing the direction of the force.

TEXT. The fulcrum of a lever is correctly described as the point on which the lever pivots or turns. At this grade level, the three classes of levers are not taught by name. It is sufficient to show that levers may differ in arrangement of the fulcrum.

The part of the lever from the force to the fulcrum is known as the *force-arm* and the part from the weight to the fulcrum is the *weight-arm*. For a small force to lift a greater weight, the force-arm must be longer than the weight-arm.

In the picture on page 75, one boy can lift five boys because the five boys (the weight) are nearer the fulcrum than the one boy (the force). The lever increases the force.

Procedure

Interest in this problem on levers will be increased if the teacher asks whether anyone can use the board and block to lift another pupil in the class. Suggest that they use the pictures in the problem to help them if they cannot otherwise figure out how to do it. Let them discover anything that they can about moving the block various distances.

After this experience, have them perform the experiments suggested in the last paragraph on page 74 and on page 75. Do not let the pupils read any more of the text than that which describes how the experiment should be performed, since for the rest of the problem they need to know the meaning of the term *fulcrum*. Let them draw such conclusions as they can from the experiments. They should be able to see how the force and the weight lifted have a relationship to the position of the fulcrum. After they have discussed their findings, they may read the problem to find additional ideas that they had not discovered for themselves. As an assignment, ask pupils to look for examples of places where levers are being used and to report them to the class.

Since this section on levers is long, it should be broken into two lessons. The second lesson should begin with page 76 after pupils have reported their observations of levers.

In introducing the remaining material (beginning on page 76), have pupils try the experiment with the nail in the board described on page 76. Let them try to pull the nail without the hammer. Then let them try it with the hammer. Help them identify the weight, the force, and the fulcrum.

After this experience, use the pictures on page 77 by asking pupils to locate the force, fulcrum, and the place where the work is done. Ask them first to find out how the nutcracker is different from the other levers they have used. (The fulcrum is at one end in the nutcracker.) After this difference has been pointed out, have the children examine the other pictures to see where the force and fulcrum are.

The remainder of the text may then be read. Ask the pupils to make a list of the important ideas that they have learned about levers. They should include the concepts given on page 40 of this *Guidebook*.

Questions (Page 77)

1. *Nutcracker:* Fulcrum is the hinge; force is put at the other end; the work is done on the sides. Increases the force of the hand. *Scissors:* Fulcrum is the point at which the blades are joined; force is put at the handles; work is done along the blades. Resulting work is better, faster, and easier than any other sharp instrument could do. *Crowbar:* Small stone is the fulcrum; force is applied at the long end of the bar; work is done at the short end. Easier to lift or move heavy objects than by muscles alone, since it increases the force of the muscles and changes the direction of the force. *Tack puller:* The place just back of the claws where it rests against the board is the fulcrum; force is applied at the end of the handle; work is done by the short prongs. Increases force and changes direction of force. Probably could not pull the tack with fingers alone. *Rowboat:* The fulcrum is at the ends of the blades in the water; force is applied at the short ends or handles; work is done at point where the oars are attached to the boat (oarlocks). Increases force. Could not move a large boat with hands alone. *Snow shovel:* Fulcrum is at the point where hand holds the shovel; force is put at the handle by the other hand; work is done at the lower shovel end. Does a greater amount of work than could be done with hands alone. *Baseball bat:* Fulcrum is at the end of the bat nearest us; force is put on the handle, work is done at the long, larger end. Makes bat move faster. *Broom:* Fulcrum is at top end of broom; force applied to handle; work done at floor end. Increases sweep of broom. *Sugar tongs:* Fulcrum is at the curved hinge; force is applied at the sides; work is done at the ends.
2. Put the fulcrum as close to the weight as possible.
3. Put the fulcrum between the weight and the force. Pushing down on one end of the lever pushes up on the other.
4. You. Short end. (The heavier child should be nearer the middle. The nearer he is to the fulcrum, the easier it is to lift him.)

How do we use inclined planes? (Pages 78-81)

Concepts

1. A weight can be pushed or pulled up an inclined plane more easily than it can be lifted.
2. A wedge is two inclined planes joined together.
3. A screw is an inclined plane that winds around as it climbs.

Experiments and observations

Pages 78-79: To show how an inclined plane makes work easier.

Materials: Two smooth boards—one about four feet long and six inches wide, the other eight feet long—strong cord, large book or other weight, books, spring balance, table.

Page 81: To show that a screw is an inclined plane.

Materials: Square piece of paper, scissors, pencil.

Procedure

This problem combines the inclined plane, the wedge, and the screw and shows how they are alike. The experiment described and illustrated on pages 78-79 will be a very good introduction. Let the pupils read the directions carefully, assemble the materials, perform the experiment, and try to answer the questions in the text. In doing this experiment they should read the spring balance after the book has begun to move, because more force is used in starting to move the book. To make sure that pupils understand the meaning of the words *inclined* and *plane*, let them read the explanation of these terms on page 78. After they have read the text and performed the experiment, the pupils may discuss the pictures on page 78 by telling how these inclined planes make the work easier. Then have them suggest places where they have seen other inclined planes being used. The first paragraph on page 80 suggests some places the pupils may not think of.

A simple wedge made of wood like the one pictured on page 80 (upper left) will help pupils see that a wedge is really two inclined planes put together. Ask the pupils to bring examples of wedges to class. Then page 80 may be read and discussed along with the wedges that have been collected.

Introduce the section on screws by having the pupils perform the demonstration pictured on page 81. Each child should do this for himself to make the idea clearer. After the demonstrations, let the pupils read page 81.

Questions (Page 81)

1. By setting up an inclined plane and showing with a spring balance the actual number of pounds of force each way uses.
2. Ramp up which people, cars, or cattle can be moved more easily than if they have to be lifted. Planks from ground to truck floor on which boxes, barrels, or heavy furniture can be pushed instead of lifted. Track along which automobiles can be driven into auto-carriers instead of lifted. Jack used to lift automobiles. Sloping trail or road along which it is easier to climb a hillside than to go straight up.
3. Wedge; each side is an inclined plane. Screw; it is an inclined plane wound around in a spiral.
4. Lever and inclined plane (wedge).

How do we use pulleys? (Pages 82-87)

Concepts

1. A fixed pulley can be used to change the direction of a force.
2. A movable pulley can be used to increase the force.
3. Pulleys can be combined in a block and tackle. The more movable pulleys that are used, the easier it is to move the weight.

Experiments

Page 82: To make a fixed pulley.

Materials: Strong spool, large nail, three small pieces of wood, screw eye.

Pages 82-83: To show how a fixed pulley is used.

Materials: Pulley, strong cord, weight (pail or basket filled with sand, stones, etc.), spring balance, hook or nail.

Page 85: To show how a movable pulley is used.

Materials: Pulley, strong cord, weight (pail or basket filled with sand, stones, etc.), spring balance, hook or nail.

Page 86: To show how a block and tackle makes work easier.

Materials: Two pulleys, two pulley blocks, each with two wheels, strong cord, spring balance, weight.

Information for the teacher

Picture. Page 87. The lifeboat is being lifted by a block and tackle. This enables the men to lift the heavy boat higher than their heads.

Text. Pulleys may be brought from home by the pupils or may be bought at the ten-cent store. The pupils can also easily make one by following the directions given on page 82. If a home-made pulley is used in the experiments, be sure that it is made strong enough to avoid accident.

With fixed pulleys, things can be moved to places otherwise impossible or difficult to reach. For example, a man down in a pit could lift materials to the top without having to climb out of the pit. But there is no mechanical advantage in using a fixed pulley, that is, the force required is not lessened. (*Mechanical advantage* means the ratio of the force produced by a machine to the force applied to it.) With the fixed pulley, the weight and the force needed to lift it are equal; and the force and the weight move an equal distance. (The mechanical advantage is 1.) It is easier to pull down than to lift up. In pulling, a person has the weight of his body to help him.

With a movable pulley, a mechanical advantage is obtained. The force needed to lift the weight is less than the weight, but the force moves farther than the weight. Less force is needed, but the force has to move through a greater distance than without the pulley. When several movable pulleys are used together in a pulley block, the work becomes still easier. The more strands of rope that support the weight, the more easily the weight is lifted, that is, the greater the mechanical advantage.

Procedure

In preparation for this problem, ask some interested pupils to make the pulley pictured on page 82. Several pupils can make such pulleys and use them.

This section may be introduced by discussing this question: "How do you think our world would be different if the wheel had never been invented?" Following this discussion, the first three paragraphs on page 82 may be read. The pupils may then use the pulley that they have made to do the experiment described in the next four paragraphs. Let as many pupils as possible do the experiment with the pulley so that they can notice how the pulley makes the work easier.

Have the class read the rest of page 83 and all of page 84. After page 84 is read, have the pupils suggest additional places where they have seen pulleys used. Write a statement on the board that tells how fixed pulleys help us. Be sure that the pupils realize that they have used only one type of pulley—the *fixed* pulley, that is, a pulley that does not move.

As with levers, the problem on pulleys should be divided into two lessons. The second lesson is devoted to a study of the movable pulley. Begin the study by having the class do the experiments pictured on pages 85 and 86. After the results have been discussed, let the pupils read pages 86-87. The last paragraph on page 87 gives the essential understandings for this problem on pulleys. Ask pupils to show, in as many ways as they can, that they really understand these ideas.

Questions (Page 87)

1. Change the direction of the force; increase the force.
2. By using a single movable pulley.
3. Several. The more pulleys there are, the easier it is to lift the weight.
4. *Fixed pulley:* Does not increase force but changes the direction of force; makes our work easier; is fastened in one place. *Movable pulley:* Moves with the weight; lifts a heavier weight with a smaller force. *Pulley block:* Several pulley wheels set side by side in one frame; used to lift heavy weights; more pulley wheels require less force. *Block and tackle:* Two pulley blocks and the rope that runs over their wheels; used in lifting such weights as pianos, boats, elevators, and extremely heavy weights.
5. Moving heavy objects, such as furniture, cars, machinery, etc.; in window frames; for clotheslines strung high up, etc.

How do we use a wheel and axle? (Pages 88-90)

Concept

When a big wheel is fastened to a small axle, a little force on the wheel will move a heavy weight attached to the axle.

Experiment

Page 88: To make a wheel-and-axle machine and to show how it works.

Materials: Board one inch thick and six inches wide, saw, auger, cardboard, nails, tacks, three pieces of wood for frame, cord, clamp, weight, spring balance.

Information for the teacher

Picture. Page 90. *Right.* In the crane on the tow truck, the crank at the side of the truck is the wheel; and the larger wheel around which the chain travels is the axle.

Procedure

In preparation for this problem, the pupils should make a wheel and axle. Let the pupils read page 88, then perform the experiment and discuss the result. After this, ask the pupils to name other wheels and axles in the schoolroom. Probably no one will think to name the doorknob. Let pupils read pages 89-90. Have them take the doorknob apart, as suggested, to see how it operates. Page 89 gives the essential concept to be understood about the wheel and axle—a small force produces a larger force. Use the pictures on pages 89-90 to suggest further uses for the wheel and axle.

Questions (Page 90)

1. The axle in a pulley is not attached to the wheel and so does not turn with the wheel.
2. On the wheel. The wheel turns the axle, which does the work.
3. You turn the wheel (the knob), which turns the axle and does the work.
4. So that just a slight turn on the wheel will turn the rod with more force.

How can one wheel turn another wheel? (Pages 91-92)

Concepts

1. One wheel can be made to turn another wheel by connecting them with a belt.
2. One wheel can be made to turn another wheel by fitting them together as gears.
3. A big wheel turning slowly will make a little wheel turn rapidly.

Information for the teacher

The teeth of a gearwheel are also called *sprockets*. Gearwheels on a bicycle are often referred to as sprocket wheels.

More than two gears working together are known as a train of gears. (Picture, page 92.)

Procedure

In preparation for this problem, ask pupils to describe any places where they have seen one wheel turn another. Bring a bicycle into the schoolroom so they can see how one wheel turns another. Have them examine an egg beater to see how wheels turn at different speeds. Then read and discuss pages 91-92.

Questions (Page 92)

1. Faster. Egg beater.
2. Slower. Sewing machine.
3. Belt, gears.
4. Gearwheels prevent slipping because the teeth fit into each other.
5. This number will vary, depending on how the bicycle is geared. A high-gear bicycle has a large front sprocket wheel and a small rear sprocket wheel, thus giving a great increase in speed and distance. A low-gear bicycle has a smaller front sprocket wheel and a larger rear sprocket wheel; though, of course, the front is still larger than the rear. This arrangement gives less increase in speed and distance, but less force is required in going up hills. The rear wheel may go around five times, three and one-half times, two and one-half times, etc., depending on the kind of bicycle.

How can we make machines work better? (Pages 93-97)

Concepts

1. Friction results when two things rub against each other.
2. Friction wastes energy and thus requires extra force.
3. Friction is reduced by making surfaces as smooth as possible.
4. Friction causes materials to wear out and to become very hot.
5. Friction is reduced by using oil, grease, wheels, rollers, and ball bearings.
6. Friction sometimes helps machines work better.

Experiments and observations

PAGE 93: To show that friction is reduced by smooth surfaces.

MATERIALS: Two rough boards, two smooth boards.

PAGE 94: To show that oil or grease reduces friction.

Materials: Two flat pieces of metal; oil or grease.

Page 94: To show that friction makes heat.

Material: Penny (or other coin).

Page 95: To show that wheels or other rollers cut down friction.

Materials: Small box, sand, stones or other weights, toy wagon, one dozen round pencils, round metal balls or shot.

Information for the teacher

Friction may be defined as the rubbing of one surface against another, or the resistance to motion of surfaces that touch each other. The amount of friction is independent of the areas of contact but is proportional to the force pressing the surfaces together. For example, it takes the same force to draw a brick across a level surface when the brick is on its side as when it is on end. But the friction will be doubled if another brick of the same weight is placed on top of the first one.

For further information about friction, see a good general science text or a book such as *Physics Tells Why* (see Bibliography).

Procedure

This problem may be introduced by referring the pupils to the last sentence on page 85 and asking them whether they can figure out what this sentence means. Ask them if they can explain this statement: "Some of the force that is used in a machine is always wasted." From the discussion that follows, the problem of friction and what it is and does will probably be raised. Ask pupils to give examples of friction and tell how they can reduce it. (Rubbing hands together, shoes on floor, etc.) Then have them do the experiments described on pages 93 and 94. Pupils are now ready to read from page 93 to the end of the first complete paragraph on page 95. After the reading, pupils may use the picture on page 94 as a basis for discussing what they have read.

The pictures on page 95 will raise the question of using wheels or rollers to reduce friction. As an introduction to this concept, have the children do the experiment described on page 95. After this experiment has been performed, the rest of the problem may be read and discussed.

Questions (Page 97)

1. Friction causes parts to wear out more quickly, requires more force, wastes energy by changing it to heat.
2. Keep surfaces smooth so that they slide easily. Use oil and grease to keep surfaces apart. Use wheels, rollers, and balls to make surfaces roll instead of sliding over each other.
3. To make the piece of furniture easier to move by reducing friction.
4. Heat is caused by the friction between the axles and the bearings. If the oil leaks out or is used up, a "hotbox" results.

How can we use machines safely? (Pages 97-99)

Concept

Machines can be dangerous and must be used carefully.

Information for the teacher

The National Safety Council has material on safety with machines that can be used in connection with this problem. Teachers may write to the School and College Department, National Safety Council, 20 N. Wacker Drive, Chicago 6, Ill., for a list of materials available.

Procedure

This problem on safety is very important. It is effective only if the knowledge is translated into intelligent action on the part of pupils. First have them read pages 97-99 and then discuss the ten rules on page 99. Each child should be able to tell why he should observe the rule (putting away skates, using a knife, opening a can, etc.). In order to make the ideas real, ask pupils to watch newspapers for accounts of accidents. If the cause of the accident is indicated, have the pupils tell which of the safety rules was not followed. These rules should continue to be emphasized after the unit is finished.

Questions (Page 99)

1. Answers might include getting hands too near gearwheels; using knives carelessly; leaving machines out of place; etc.

2-3. Answers individual.

Questions to answer (Page 100)

1. *Post-hole digger:* Lever; wheel and axle. *Sailboat:* Wheel-and-axle machine for steering; pulleys to help move sails. *Fixed pulleys:* Lifting a heavy object with a small force; changing the direction of the force. *Large jackscrew:* Increasing force so that one man can lift up a freight car.

2. Inclined plane, lever, wedge. Pulley, wheel-and-axle machine.

3. A fixed pulley stays in one place and only changes the direction of the pull, without reducing the force needed; a movable pulley moves with the weight and makes it possible to lift the weight with less force.

4. Wedge. Lever. Inclined plane. Pulley.

5. Examples: Pulley on windows and shades to raise and lower them; pulley on globe to raise and lower it; wheel-and-axle machine on doorknob; etc.

6. The part where the axle is supported as it turns. Friction at this part will cause heat, wear, and loss of force.

7. Answers might include: *Friction* should be kept as small as possible. In each *simple machine*, there are only a few parts (or all machines are made up of simple machines put together). The support of a lever is the *fulcrum*. *Belts* are one way of making one wheel turn another. *Gearwheels* are used to keep wheels from slipping on each other as they turn. *Ball bearings* help to reduce friction when one part of a machine turns on another.

8. Some machines would not work without friction. Driving on snow with skid chains, putting "friction" tape on a baseball bat, etc.

9. Much more primitive.

Things to do (Pages 100-101)

1. Pupils may look at carpenter's tools, kitchen utensils including egg beaters and wall-type can openers, and many other tools using one or more simple machines.

2. Answers individual.

3. Many magazine and newspaper articles and advertisements show machines.

4-6. Individual or class activity.

UNIT 4. *How Do Heating and Cooling Change Materials?*

Purpose and scope

In this unit as in the previous one, there are again many examples in the immediate environment of the pupils that illustrate the science principles. Through a study of this unit, pupils will become more aware of the effect of heating and cooling on the solids, liquids, and gases that they encounter each day. For many pupils, the ideas in this unit are quite new. They probably have observed examples but never thought enough about them to be genuinely curious. The unit should, therefore, increase interest in this phase of science.

A study of how some home heating systems operate forms an important part of the unit, and there should be ample opportunity for pupils to observe them first-hand. If new buildings are being erected near the school, the installation of the heating units will interest the pupils.

The science principles taught in this unit are necessary for an adequate understanding of later units of the series such as *Discovering Our World, Book Three*, Units 2 and 3.

Science background

All Around Us: Unit 3, Sun, Wind, and Weather

Discovering Our World, Book One: Unit 2, Why Do All Living Things Need Air and Water? Unit 5, What Can We See in the Sky at Night?

Discovering Our World, Book Two: Unit 2, What Makes Things Move?

General concepts

1. Heating makes solids, liquids, and gases expand, or get larger.
2. Cooling makes solids, liquids, and gases contract, or get smaller.
3. When liquids or gases expand, they become lighter.
4. Heating melts some solids.
5. Heating makes some liquids change to gases.
6. Liquids change to gases, or evaporate, at less than boiling temperatures.
7. Gases change to liquids, or condense, when they are cooled.
8. Hot water and hot air are used to heat houses.

Introducing the unit (Page 103)

Information for the teacher

The picture on page 102 shows a steel works where molten iron is being taken from cupolas, or small blast furnaces, where it has been purified. Materials will now be added to convert it into steel.

Procedure

The incident described in the introductory section may be used to introduce the unit. After it has been read, ask pupils to see if they can explain what happened. Such a discussion will lead directly into the first problem, and to the experiment pictured on page 104.

How do heating and cooling change the size of solids? (Pages 103-106)

Concepts

1. Heating makes most solids expand, or get larger.
2. Cooling makes most solids contract, or get smaller.
3. In many common uses of solids, allowance is made for expansion and contraction.

Experiments

PAGES 103-104: To find out what heat does to solids.

MATERIALS: Copper or iron wire about three feet long, two supports, small stone or weight, source of heat (alcohol lamp or bunsen burner if possible).

PAGE 104: To find out what heat does to a solid.

MATERIALS: Strip of metal, nails, board, source of heat.

Information for the teacher

PICTURES. PAGE 104. Home-made supports, such as shown in the picture, or ring stands may be used for this experiment.

PAGE 105. The apparatus for this ball and ring experiment can be purchased from a scientific supply company if desired. (See page 95.)

TEXT. In the experiment with the strip of metal nailed to the board, the metal strips will get longer and buckle on the board to which they are nailed.

Telephone wires are not stretched tightly because in cold weather they contract and would be likely to break.

Procedure

Have the pupils perform the experiments on pages 103-104 and let them offer their explanations. If the ball and ring pictured on page 105 are not available, use the pictures instead and ask pupils to explain what is happening and to tell why they think it is happening.

After these experiments have been performed, ask pupils to make a general statement describing what they have learned about the problem. Write this statement on the board. Then ask pupils to try to think of other places where they have seen that heat causes solids to expand and cooling causes them to contract. After their examples have been given, they may read the problem to find other examples and to find additional information that they themselves had not discovered. The pictures on pages 103 and 106 show common examples of the science principles. Ask pupils to identify them. See also *Things to Do*, page 123, No. 2.

Questions (Page 106)

1. So that they will leave room for changes in size when building or working with solids.
2. *Contract* means get smaller; *expand*, get larger.
3. No, because the iron frames will contract when they get cold.
4. No, they should let the wires sag, because in cold weather the wires will contract and may break.
5. The concrete would expand and crack.

What happens to liquids when they are heated or cooled? (Pages 107-109)

Concepts

1. Heating makes most liquids expand.
2. Cooling makes most liquids contract.
3. When liquids expand, they become lighter.
4. Warm water is pushed upward by the colder, heavier water, which sinks.

Experiments

PAGES 107-108: To find out what happens to a liquid when it is heated and cooled.

MATERIALS: Test tube, rubber or cork stopper with hole, glass tubing about one foot long that fits hole in cork, red ink, clamp or test-tube holder, source of heat, tape or label.

PAGE 108: To show what happens to liquids when they expand.

MATERIALS: Glass jar, coarse sawdust, source of heat.

Information for the teacher

PICTURES. PAGE 109. This same principle is applied to other types of water heaters that the pupils may have in their homes. Sometimes a storage tank is connected with a kitchen stove. The water is heated by a coil of pipes or a water front (similar to the coils in the picture on page 109). In many buildings, heating coils are placed in the fire boxes of furnaces. These coils are connected with a storage tank. Both of these types of water heaters have the disadvantage of being able to supply hot water only when a fire is burning in the stove or furnace.

TEXT. PAGE 107. The red or blue liquid in such thermometers is alcohol.

To prevent accidents the teacher should set up the equipment for the experiment. To put the glass tubing into the stopper, wet both the tube and the stopper. Twist the tube gently into the hole in the stopper. It is a good plan to hold the tubing with a cloth or towel to prevent cutting the hands if the tubing should break.

PAGE 108. The liquid rises in the thermometer because the warmth of your finger on the bulb makes the liquid in it expand.

The teakettle will boil over because the water expands when it is heated.

When the tomato juice cooled, it contracted so that the jars were no longer full to the top.

Procedure

Ask pupils to tell what they think the answer to the new problem is. Then ask them if they are sure. If they answer "yes," ask them how they can be sure. Pupils are likely to assume that the answer to this problem is the same as that for the previous one. But when they are asked to be certain, they should realize that they cannot be sure by guessing, that they must produce evidence. In this case, the evidence comes from reading and experimenting.

Have the pupils perform the experiment pictured on page 107. Then ask them to tell what the experiment shows. They should say that it shows that heating causes liquids to expand and cooling causes them to contract. It shows that this is true only for the liquid used, water. In order to be sure about other liquids, they need either to experiment further, or read or both.

After pupils have read to the next-to-the-last paragraph on page 108, they are ready to learn another important thing about heating and cooling liquids. The experiment pictured on page 108 helps to explain this idea. After performing the experiment, pupils should try to explain why the water circulates. Then they should read the text to check their explanation, which will probably be incomplete.

After they understand what the experiment shows, ask them if they know of any place at home where this same principle operates. If they have a hot-water heater at home, ask them to find out how it works. Use the diagram on page 109 to help them understand. Ask various pupils to give a complete explanation of the diagram.

Questions (Page 109)

1. It expands when heated and contracts when cooled.
2. The cold water on the side not being heated is heavier than the warmer water. It sinks to the bottom and pushes the warmer water up, thus causing a current.
3. The water will run out of the radiator, because there is no room for it to expand.
4. No. When it is heated, the water will expand and run over.

How is hot water used to heat a house? (Pages 110-111)

Concept

Hot water can be used to heat houses.

Information for the teacher

Picture. Page 110. The expansion tank in the attic is a safety device. If water were heated in a closed hot-water system full of water, expansion of the water would burst some part of the system. The expansion tank placed above the highest radiator prevents this kind of accident and yet allows the pipes to be full of water. The tank may overflow onto the roof or into a pipe that carries the water down to a drain in the basement. The currents of hot water in the heating system are *convection currents.*

Procedure

The diagram on page 110 shows how hot water may be used to heat a home. Let the pupils study the picture carefully, read the text, and then use the four questions on page 111 as a guide for discussion. If it is possible to examine a hot-water heating system, that experience will be very helpful in understanding the idea and in making it real.

Questions (Page 111)

1. Cold water is heavier than the same amount of warm water. The cold water sinks down through the pipes to the furnace and pushes the warm water up to the radiators.
2. Part of the hot water from the furnace turns off and goes to the radiators on the first floor, returning from there to the furnace. The rest of the hot water continues on up to the next floor into the radiators there.
3. The tank allows for the expansion of the water when it is heated. (Pupils should recall the experiment on page 107.)
4. The hot-water pipes are connected to the top. The cold-water pipes are connected to the bottom. Cold water sinks and pushes the lighter, warmer water up into the radiators.

How do heating and cooling change gases? (Pages 111-115)

Concepts

1. When gases are heated, they expand.
2. When gases are cooled, they contract.
3. When gases expand, they become lighter.
4. Warm air is pushed upward by colder, heavier air, which sinks.

Experiment

Pages 111-112: To show that air expands when it is heated and contracts when cooled.

Materials: Toy rubber balloon, bottle with a small mouth, pan, water, source of heat, ice or other means of cooling.

Page 112: To show that air expands when heated and contracts when cooled.

Materials: Small-mouthed bottle, ice or other means of cooling, glass, water, source of heat.

Page 113: To show that air has weight.

Materials: Basketball or volleyball, pair of scales, bicycle pump.

Pages 113-114: To show how air currents are caused.

Materials: Wooden box, piece of glass that will cover open side of box, two lamp chimneys, small candle, matches, splinters of wood or rolls of paper, small piece of cardboard.

Procedure

The same procedure described for the two similar problems dealing with solids and liquids may be used here; that is, experimenting first, drawing such conclusions as are possible from the experiments, and then, after each experiment, reading the text for additional information and to check the conclusions.

If a pair of scales such as those shown in the picture on page 113 is not available, make a simple balance with a slender stick and support it with a string tied to the middle. In the experiment pictured on page 114, be sure that care is exercised with the candle and burning splinter to prevent fire or burns.

Questions (Page 115)

1. The air in the tire will expand on a hot day and cause so much pressure that if the tire is old and not very strong, it will blow out.
2. (*a*) expand; (*b*) contract; (*c*) heavier.
3. Softer. The air inside will contract as it cools.
4. Expand when heated, contract when cooled.

How does a hot-air furnace heat a house? (Pages 116-117)

Concept

Hot air can be used to heat a house.

Experiments

Page 117: To find out whether air is warmer near the ceiling in a room.

Materials: Two thermometers.

Page 117: To show how air currents move in a room.

Materials: Window pole, strips of paper.

Information for the teacher

Picture. Page 116. In the hot-air heating system, currents of air are created in the same way that they are in the hot-water system. These currents of air are also convection currents.

Procedure

In this problem, the pupils are ready to apply the ideas that they have learned about heating and cooling gases. The three numbered items on page 113 should be recalled and written on the board. The pupils should study the diagram of the house on page 116 and the room on page 117, perform the experiment suggested on page 117, and then try to explain how the hot-air furnace heats the house. Encourage pupils to observe their home heating system to see whether it is like this. See also *Things to Do*, page 123, Nos. 7 and 8.

Questions (Page 117)

1. Air heated in the furnace expands and becomes lighter. Heavier, colder air sinks and pushes the warmer air up into the rooms.
2. The colder, heavier air in the rooms sinks down through the cold-air registers to a pipe that leads to the bottom of the furnace. The warm air, which has been heated by the furnace, is pushed up through the warm-air pipe, out through the hot-air registers into the rooms and up to the ceilings. As the air cools and becomes heavier, it sinks down again into the

cold-air register and pipe and back to the furnace to be heated.

3. Open the windows both top and bottom so that a current of moving air is started. The cool air comes in the bottom, pushing the warm air out at the top.

How are solids changed to liquids? (Pages 118-119)

Concepts

1. Different solids melt at different temperatures.
2. The temperature at which a solid melts is called its melting point.
3. The ability to melt metals enables us to mold them into shapes and to mix metals together to make more useful materials from them.

Experiments

Page 118: To observe that different solids have different melting points.

Materials: Iron pan, butter, paraffin, lead, aluminum, source of heat.

Page 118: To find the melting point of ice.

Materials: Ice, pan, thermometer.

Information for the teacher

Pictures. Page 118. The ice will melt first, next paraffin, then lead.

Page 119. This picture may be used also to review the pupils' knowledge of simple machines by asking what kind of machine is being used to tip the bucket of molten aluminum. It may recall also what they learned about the change of color of metals when heated, in *Discovering Our World, Book One*, Unit 5.

Text. A high-school physics or chemistry book will give a table of melting points if the teacher wants one for reference.

The Fahrenheit scale is one commonly used on thermometers in this country. Scientists use thermometers with the Centigrade scale.

Anything made by pouring it into a mold and allowing it to harden is called a *cast* or a *casting*. Making something in this way is called *casting*. Many of the metal parts of the seats in the schoolroom are castings.

Mixtures of metals are called *alloys*. The children should recall the alnico magnet in *Discovering Our World, Book One*, Unit 6.

Procedure

Pupils have had experiences such as melting butter, paraffin, etc., that will help them to answer this problem. The idea that a solid has a melting point is, however, new to them. Have the pupils do the experiments on page 118 and draw their own conclusion. After the pupils have read the problem, suggest that they try to find pictures and examples of how we mold materials into things that we need and use.

Questions (Page 119)

1. The temperature at which a solid becomes a liquid.
2. So that they may be easily molded into useful shapes or mixed to form more useful materials.
3. The melting point of lead is too low. Lead pans would melt when food is cooked.
4. To make them more useful (harder, rust-resistant, etc.).

How are liquids changed to gases? (Pages 120-121)

Concepts

1. When a liquid boils, it changes to a gas.
2. Different liquids boil at different temperatures.
3. The temperature at which a liquid boils is called its boiling point.
4. A liquid does not get any hotter than its boiling point.

Experiments

Pages 120-121: To show that heat makes a liquid evaporate faster.

Materials: Two pans just alike, water, source of heat.

Page 121: To show that some liquids evaporate faster than others.

MATERIALS: Two saucers exactly alike, water, alcohol.

Information for the teacher

A high-school physics or chemistry book will give a table of boiling points if the teacher wants one for reference.

Procedure

Have the pupils recall experiences in which they saw liquids "disappear" (change to a gas). Recall information acquired in earlier science study, as in *Discovering Our World, Book One*, Unit 2. Then have the children read and discuss page 120 except for the last paragraph. Use the picture on page 121 to illustrate a practical use of evaporation.

Now have the pupils do the experiments at the end of the problem. The first experiment uses a *control* (the unheated pan of water). The children should understand why the control is used. If alcohol and gasoline are used in the second experiment, be sure that no open flame is brought near them.

Questions (Page 121)

1. No. Water boils at a temperature of 212°F., alcohol at 172°F.
2. Change from a liquid into a gas.
3. No. By keeping the gas or electric current turned up just high enough to make the water boil.
4. The heat from the sun makes the water evaporate faster.

How is water vapor changed to liquid water? (Page 122)

Concepts

1. Gases change to liquids, or condense, when they are cooled.
2. Water vapor in the air condenses if the air is cooled enough.

Procedure

This problem has probably been solved earlier in the science experience and needs only to be reviewed here. Pupils should recall experiences with condensation in earlier study, as in *Discovering Our World, Book One*, Unit 2. Actual experience of watching a boiling teakettle and holding a cold plate above the spout will help to make the concepts real. If the pupils examine a boiling teakettle, caution them to keep their fingers away from the scalding steam.

Questions (Page 122)

1. Change from a gas to a liquid.
2. It must be cooled enough.
3. No. Steam is water vapor, an invisible gas.

Questions to answer (Page 123)

1. The heat will cause the glass to expand. The inside, which is heated more quickly, will expand first, causing the outside to crack and pull away. Avoid pouring very hot water on glassware.
2. The carbon-dioxide gas expands as it is heated and pushes the dough out.
3. Warm air from a radiator or register is pushed up to the ceiling, carrying with it dirt from the floor and other parts of the room.
4. Steam is a very hot gas. Smoke is mostly a mixture of hot air and other gases. These hot gases are usually lighter than the air around them. So they are pushed up by heavier, cooler air, which sinks.
5. The air in the house contains water vapor. When this air strikes the cold windowpane, the air is cooled and the water vapor condenses on the window. The water comes from the water vapor, which condenses.
6. The metal rims expand when heated. When they cool, they contract and fit the wheels tightly.
7. Heat the neck of the bottle to expand it but be careful not to heat the stopper, too.
8. The warmest water will be on top, and the coldest water on the bottom. The cold water is heavier. It sinks and pushes warm water up. Also, the sun heats the water on top and that water stays on top, because it is lighter than the colder water below.

9. Your breath contains water vapor. When you breathe out on a cold day, the water vapor condenses when it hits the cold air. Then you can "see your breath." On a warm day the water vapor does not condense.

Things to do (Page 123)

1. Dry ice is carbon dioxide in solid form. Its temperature is about 110° F. below zero.

2. At red heat, rivets are soft and expanded. When put into the holes in the beams and hammered, they are spread out to form a head at each end. When they cool, they contract and hold the beams tightly together.

3. Such items as kitchen utensils, glass, lead wire, or "sinkers," objects that are soldered, coins, jewelry, candles.

4. Water expands when it freezes. Fill a bottle with water. Put a cork in the bottle and wire the cork on. Put the bottle in the freezing compartment of a refrigerator or set it outdoors on a night when the temperature is freezing. Look at the bottle the next day. The bottle will be cracked by the force of the water expanding as it froze.

5. Most liquids contract when they "freeze," but water expands when it freezes. (Melted copper and type metal are liquids which also expand when they cool and harden.)

6. Antifreeze can be obtained at service stations, garages, and hardware stores.

7. Arrows should show current rising at stove, falling at points farthest from it, and pushing toward it near the floor.

8. Because warm air around register, stove, or radiator is lighter and so is pushed upward by heavier, cooler air.

9. See a dictionary or encyclopedia.

UNIT 5. *What Are Things Made Of?*

Purpose and scope

The concepts in this unit will be entirely new to most of the pupils. However, experience indicates that the children are greatly interested in learning about materials. As the concepts are here developed, they are very easily understood. Many of the concepts are essential in later science work; for example, an understanding of chemical change is required as background for later units of this book and also for Units 3, 4, and 5 of *Discovering Our World, Book Three*. All of the ideas are valuable in interpreting things that happen in the pupils' environments.

Science background

Discovering Our World, Book One: Unit 2, Why Do All Living Things Need Air and Water? Unit 3, How Does Your Body Work? Unit 7, How Can You Keep Well?

Discovering Our World, Book Two: Unit 1, How Do Living Things Help and Harm Each Other? Unit 2, What Makes Things Move?

General concepts

1. Every material has characteristics by which we tell what kind of material it is.

2. The use made of a material depends on its characteristics.

3. Physical change is a change of characteristics without making a new material.

4. Chemical change is a change of characteristics in which a new material is produced.

5. Everything is made of elements.

6. Elements join together, or combine, in chemical change to make compounds.

7. We use chemical changes to produce new materials and to produce heat.

8. Harmful chemical changes can be prevented.

Introducing the unit (Pages 125-126)

Ask each pupil to take one thing from his pocket or desk and place it before the class. Then the pupils should be asked what they think these things are made of. After discussion, the pupils may read the introduction. Then ask why they do not believe as people did 2000 years ago.

How are materials different from each other? (Pages 126-129)

Concepts

1. Every kind of material has characteristics by which we tell what kind of material it is.
2. The use made of a material depends on its characteristics.
3. Acid turns blue litmus paper red; this is a test for acid.

Observations and experiments

Page 126: To observe the characteristics of materials.

Materials: Materials of different kinds collected by pupils.

Page 128: To show that litmus paper is an acid indicator.

Materials: Litmus paper, vinegar, lemon, baking soda.

Information for the teacher

Pictures. Page 127. The materials in the picture are potato, sugar, onion, wax (candle), copper (candle holder), rubber bands, pencil, nails, soap, glass, and water. The pupils may list such characteristics as: potato—a solid with a smooth covering, white inside; sugar—hard, rough material, white in color, sweet in taste, will dissolve in water, etc.

Page 128. The acid in the vinegar made the blue litmus paper turn red.

Page 129. Test these materials with litmus paper. Place the litmus paper against the cut surface of the fruits to moisten the paper. The vinegar, lemon, root beer, and tomato should show acid. Litmus paper may be bought at a drug store. It may be either red or blue. Acids make blue litmus turn red. Alkalis turn red paper blue. The baking soda in water would turn red paper blue. It does not have acid in it. It is alkaline. The paper may be used over and over when it is dried.

Procedure

As an introduction to the problem, ask the pupils how the materials collected by the class are different from each other. After the discussion, pupils should read the problem over to the end of the first paragraph on page 128. Then let pupils tell the characteristics of the different materials they have been looking at. Also have them select various things in the room and tell what characteristics these things have that make them useful for the purpose which they serve.

If litmus paper is available, the experiment described in the picture and text on page 128 should be performed. Pupils may wish to bring some of the things pictured on page 129 and test them with litmus paper. After this, have them read the rest of the problem for additional information. The safety rules on page 129 should then be discussed.

Questions (Page 129)

1. Strong, does not melt or burn easily, can be molded into shapes.
2. Cut the oranges and apples and apply blue litmus paper against the cut surface. If the litmus paper turns red, there is acid in them.
3. Stiff; easy to cut, carve, put together; lasts a long time; attractive.
4. Cellophane is stronger, more waterproof, and more transparent than tissue paper.

How can we change the characteristics of materials? (Pages 130-133)

Concepts

1. Physical change is a change of characteristics without making a new material.

a) Changing a material from solid to liquid or liquid to gas does not change it chemically; it is still the same material.

b) Dissolving a material does not change it chemically; it is still the same material.

2. Chemical change is a change of characteristics in which an entirely new material is produced.

Experiments and observations

PAGES 130-131: To show chemical change by burning sugar.

MATERIALS: Test tube, or metal lid from a jar or can, sugar, test-tube holder, source of heat.

PAGE 132: To show chemical change by burning wood.

MATERIALS: Splinter of wood, metal pan, matches.

PAGES 132-133: To show chemical change in starch.

MATERIALS: Piece of bread or cracker.

Information for the teacher

PICTURES. PAGE 132. The chemical change involved in burning the leaves and the one involved in the changing of the green leaves to the autumn colored ones are shown.

When wood and other materials burn, a chemical change takes place. Oxygen from the air combines with carbon and hydrogen in the burning material and makes compounds. The carbon in the wood combines with the oxygen and escapes as carbon dioxide. Oxygen and hydrogen also combine to form water, which escapes as water vapor. Mineral materials are left in the form of ash. The chemistry of burning is treated in more detail in the next unit of this book.

Procedure

Ask pupils to indicate how they have ever changed the characteristics of a material. Then ask them to observe carefully while they see two changes made—a match is broken into two pieces, another is burned. How are these changes alike? How are they different? This will lead to a discussion of the two kinds of changes. Let pupils read down to the experiment with sugar on page 130. Be sure that they understand the meaning of *physical change* before they go on to a study of *chemical change.*

Now have them perform the experiment with sugar and try to decide what has happened. Then let them read the text as far as the last paragraph on page 131. After a discussion of the meaning of chemical change, ask the pupils to contrast the picture on page 130 with the one on page 131 to review the difference between chemical change and physical change. Then pupils should list chemical changes that they see taking place around them every day. Then the remainder of the text should be read to find additional examples. In the experiment with bread or a cracker on page 132, have the pupils recall that saliva helps digest food. (*Discovering Our World, Book One*, Unit 3.)

Questions (Page 133)

1. A chemical change changes the material to a new one; it makes a new material with different characteristics. A physical change takes place when a material changes in form or shape but does not change into a new material. Chemical change: heating sugar. Physical change: dissolving sugar.

2. No. The potatoes change in appearance but not in characteristics. They are the same material as before.

3. In burning a piece of wood, you are changing the wood into a different material. In melting iron, you are only changing the form of the material.

4. Change them into different materials with different characteristics.

5. Wood: stiff, light color, definite size. Wood ashes: soft, crumbly, of a gray or black color, smaller than the original piece of wood. (The ashes are only part of the material in the wood.)

6. *Same:* size and shape. *Different:* color; materials inside the leaf.

7. Help keep us alive; they take place in our bodies constantly; change food into blood, bones, etc.

What are elements? (Pages 133-135)

Concepts

Everything in the world is made of elements.

a) An element is the simplest kind of material; it is made only of itself, not two things put together.

b) There are ninety-eight known elements.

c) Some elements are solids; some are liquids; some are gases.

Observation

PAGE 134: To observe different elements.

MATERIALS: Objects of iron, gold, copper, lead, silver, sulphur, and other elements.

Information for the teacher

A complete list of elements may be found in any high-school chemistry book. Consult the latest editions for the new elements that have been discovered in the last few years, raising the number of known elements from ninety-two to ninety-eight. The new ones are neptunium, plutonium, americium, curium, berkelium, and californium.

TEXT. PAGE 135. The elements in the materials mentioned in the last paragraph are:

Material	*Elements*
Water	Hydrogen, oxygen
Carbon dioxide	Carbon, oxygen
Salt	Sodium, chlorine
Sugar	Carbon, hydrogen, oxygen
Washing soda	Sodium, carbon, oxygen
Alcohol	Hydrogen, oxygen, carbon
Baking soda	Sodium, hydrogen, carbon, oxygen

Procedure

The pupils are ready to consider the problem of what elements are. As an introduction, let the pupils read the two paragraphs on page 133 and then ask them whether they can name any elements. Write the names on the board and check the list later. Then have the pupils read and discuss page 134. They may wish to make an exhibit of elements as indicated in the text. A large number of elements can be collected at home, at school, or at the drug store.

The first paragraph on page 135 gives a definition of an element. Be sure that pupils understand clearly the meaning of this term. The last paragraph presents the idea of how elements are used. After the pupils have read this page, ask them to tell what they think happened when the sugar was heated in the experiment on page 130. See also *Things to Do,* page 147, Nos. 1 and 2.

Questions (Page 135)

1. An element is made only of itself, has no other material in it, and is the simplest kind of material.
2. They are colorless gases.
3. Ninety-eight.
4. A material is not an element when it can be divided or broken down into two or more materials. Examples: water, sugar, salt, alcohol, air, etc.
5. Answers may include aluminum, iron, copper, lead, gold, silver, zinc, nickel, sulphur, carbon, tungsten, etc.

How are elements joined together? (Pages 135-139)

Concepts

1. Elements join together, or *combine,* in chemical change to make compounds.
2. When a compound is made, the elements do not merely mix but combine and make an entirely new material.
3. There are a large number of compounds in the world.

Experiment

PAGES 136-137: To show the difference between a mixture and a compound.

MATERIALS: Powdered sulphur, powdered iron, beaker or dish, magnet, test tube, water, source of heat.

Procedure

Ask the pupils to read page 135 to find out what happened when sugar was heated. Then write the definition of a compound on the board and refer to it later in the problem. Then have the pupils read and discuss page 136 except the last paragraph. Stress the meaning of the word *combined* and also the fact that after elements are combined, the new material has new and different characteristics.

The next four paragraphs describe the experiment pictured on pages 136-137. In the experiment, exact amounts of the element iron and sulphur must be used, and they must be heated very hot before they will unite. They must become so hot that they glow. The teacher is cautioned to use fine iron filings or powdered iron but not *reduced* powdered iron. It is dangerous to heat reduced powdered iron. The material formed in the experiment is called iron sulphide, a compound of iron and sulphur. Break the test tube by putting it into cold water.

Have the pupils perform the experiment and draw their own conclusions. Again stress the fact that the elements must be combined to form a compound and that the compound formed possesses new characteristics. Now have the pupils read and discuss the remainder of the problem. The pictures at the bottom of page 139 will be helpful in summarizing the idea of chemical change. They introduce the idea of explaining chemical change through the use of a formula. Let the pupils make up other pictures like this from their reading. See also *Things to Do*, page 147, Nos. 6, 7, and 8.

Questions (Page 139)

1. (*d*).

2. A compound is a material made of two or more elements that have combined.

3. Pupils may list burning, heating of sugar, rusting, tarnishing, etc. ". . . an entirely different material is formed in each change."

4. When two materials are mixed together, each material keeps its own characteristics. When two materials combine, they form a new material, lose their old characteristics, and take on new ones. Experiment such as the one with sulphur and iron, pages 136-137.

5. Yes. Test sweet milk and sour milk with blue litmus paper. Only sour milk, which is acid, turns the litmus paper red.

How do we use chemical changes? (Pages 140-142)

Concept

We use chemical changes to produce new materials and to produce heat.

Information for the teacher

Pictures. Page 140. The materials for making glass are carefully weighed to obtain the correct proportions. The element silicon in sand is the chief ingredient in glass. The other materials added to the sand in the making of glass depend on the kind of glass to be made. Additional information about glass may be obtained from encylopedias or manufacturers.

Page 141. The man in the center picture is examining the pulp to see whether the proper chemical changes are taking place and whether it is ready to proceed to the next stage. More information about paper may be obtained from encyclopedias or manufacturers.

Page 142. *Left.* The making of nylon bristles for paint brushes is a complicated process, because the bristle must be tapered in order to make the brush bend properly and spread the paint well. *Right.* The windows are a shatterproof plastic glazing made of cellulose acetate.

An excellent pamphlet on plastics and their uses has been prepared by the American Association of School Administrators and may be obtained from this organization at 1201 16th St., N.W., Washington 6, D.C.

Procedure

Let pupils make a list of all the ways they can think of in which we use chemical changes. The problem should then be read and more examples added to the list. Encourage the pupils to bring to school pictures from newspapers and magazines that illustrate how chemical changes are useful. See also *Things to Do*, page 147, Nos. 3 and 4.

Questions (Page 142)

1. Glass, concrete, plaster, steel, plastics.
2. Rayon, nylon, other synthetic fabrics.
3. Steel, glass, bricks, plaster, rubber, leather, gasoline.
4. Because the cooked food often has very different characteristics from the original materials that were combined.

How can we prevent harmful chemical changes? (Pages 143-145)

Concepts

Harmful chemical changes can be prevented by

a) keeping apart the elements that combine.
b) keeping some materials dry.
c) keeping some materials cool.
d) keeping some materials out of the light.

Experiments

PAGE 143: To show that moisture brings about rusting of iron.

MATERIALS: Iron nails or steel wool, two dry dishes, water.

PAGES 144-145: To produce a chemical change by adding water to baking powder.

MATERIALS: Baking powder, cup, water.

Information for the teacher

TEXT. PAGE 145, Column 2. Peaches, pears, apples, grapes (raisins), meat (dried beef), fish (dried cod-fish flakes), eggs, milk, etc., are further examples of foods preserved by drying.

Procedure

Ask the pupils to suggest ways in which we can prevent harmful chemical changes. Write these ways on the board. Then have the pupils use the pictures and read the text to find additional ways.

Questions (Page 145)

1. By covering the materials in such a way that oxygen cannot reach them.
2. By keeping it cold and by drying it.
3. Rusting, because it makes the iron and steel unusable. Spoiling of food, because it may cause illness and also makes the food unusable.

Questions to answer (Page 146)

1. *School:* Window glass, steel in seats. *Mother:* Salt.
2. They change our food so that our bodies can use it; make possible many materials that are useful; cause burning, which keeps us warm and cooks our food, etc.
3. Chemical, because a gas is formed from the baking powder; physical, because the expanding gas raises the cake.
4. No, not correctly.
5. No. There are many compounds that heat does not affect chemically—Examples: water, carbon dioxide, iron oxide (rust).
6. Yes. The ninety-eight elements combine in countless ways to form different compounds.
7. A chemical change takes place in the dye. A physical change may take place, too. The dye may be dissolved in the water and run out of the cloth.
8. Children may tell of putting out fires, shutting out moisture, keeping food in the icebox, etc.
9. The cattle eat the food. The chemical change in digestion changes the food into material that the cattle's bodies can use. Other chemical changes change the food into meat that we later use for food.
10. Moisture may cause a chemical change before it is wanted.
11. No. Some of the characteristics of the sugar remain. Only the form has changed.

Things to do (Page 147)

1. An encyclopedia or chemistry book will give information.
2. Use general references, encyclopedia, etc.
3. Lists will vary.

4. Use encyclopedia.

5. Might include: Follow directions exactly; work carefully; keep materials and papers away from flame; handle glassware and flames with care, etc.

6. Use Bibliography, encyclopedia, etc.

7. Just mixed. Keep their own characteristics.

8. A mixture. A sediment on the bottom of the glass and other materials in the water.

UNIT 6. *How Do We Control Fire?*

Purpose and scope

The concept of chemical change developed in the preceding unit is here applied to the principles of combustion. After studying this unit, pupils should understand why fire is both useful and dangerous. They should also be aware of the need for fuel conservation.

In many respects, this is one of the most important units of Book Two because of its emphasis on safety with fire. Every effort should be made to make the safety rules functional. The teacher should refer to these rules frequently and encourage their use long after the actual study of the unit is over so as to make the rules part of the pupils' way of reacting to their environment.

Science background

Discovering Our World, Book One: Unit 2, Why Do All Living Things Need Air and Water? Unit 3, How Does Your Body Work?

Discovering Our World, Book Two: Unit 2, What Makes Things Move? Unit 3, How Is Our Work Made Easier? Unit 4, How Do Heating and Cooling Change Materials? Unit 5, What Are Things Made Of?

General concepts

1. To make a fire and keep it burning, there must be three things: (*a*) a combustible material, (*b*) enough heat to raise the material to its kindling temperature, and (*c*) a current of fresh air.

2. Heat to start a fire can be produced by friction.

3. When any material burns, it gives off heat and light and becomes smaller.

4. When any material burns, a chemical change takes place.

5. We must conserve our coal, oil, and gas because the supply will not last forever, and these fuels cannot be replaced.

6. Accidental fires can be avoided by preventing the three things needed for burning from coming together.

7. Fires can be put out by removing one or more of the three things needed for burning.

Introducing the unit (Pages 149-150)

Information for the teacher

PICTURE. PAGE 150. The handle for the damper is in the smoke pipe back of the furnace and does not show in the picture.

Procedure

Have the pupils discuss the meaning of the word *control* before beginning the unit. Some of the pupils may wish to tell the class how they have seen fires controlled. Then let the pupils read and discuss pages 149-150 to find different ways that are used to control fires. Have them compare an outdoor fire with a fire in a furnace. If possible, the school engineer should be asked to show pupils how he builds and controls the fire in the school furnace. Pupils should be asked to examine their home furnaces for the same purpose.

What do we need to make a fire? (Pages 151-153)

Concepts

1. To make a fire, there must be three things: (*a*) a combustible material, (*b*) enough heat to raise the material to its kindling temperature, and (*c*) air near the material.

   a) Materials that burn easily have a low kindling temperature; those that do not burn easily have a high kindling temperature.

   b) In building a fire, materials with a low kindling temperature are laid first so that the fire may easily be started, and the materials are arranged to allow air to get to them.

2. Heat to start a fire can be produced by friction.

3. Matches help us light fires easily, but they must be used with care.

Procedure

If a safe place is available on the school grounds, have the pupils collect materials and actually build a fire. Careful supervision is, of course, required. Have all the rules given in the introduction followed. As the fire is built and the pupils watch it burn, they can observe and discuss the steps in building, when each is necessary, and what materials are required. Then have the pupils read pages 151-153 and compare their findings with the information in the text. Use the picture on page 151 to illustrate the steps in fire building. See also *Things to Do*, page 175, No. 5.

Questions (Page 153)

1. One that will burn. Leaves, twigs, wood, paper, cloth, coal, gas, oil.
2. Matches have a very low kindling temperature. They light easily when rubbed on a rough or specially prepared surface.
3. The temperature to which a material must be heated before it will burst into flame.
4. Paper, gasoline, leaves, wood shavings, cloth.
5. Whirling a hard, pointed stick against a soft piece of wood, a piece of flint struck against steel, matches. Matches.

What do fires need to keep them burning? (Pages 154-155)

Concepts

1. To keep a fire burning, it must have a current of fresh air.
2. Kerosene lamps and gas stoves are made so that a current of fresh air can get to the burning fuel.

Experiment

Page 154: To show that a fire must have air to keep burning.

Materials: Three small candles about two inches high, lamp chimney, piece of glass, pencils or sticks, splinter of wood or roll of paper.

Procedure

The experiment pictured at the top of page 154 will help make clear the major concept in this problem. Be sure that the pupils understand that the smoke is used merely as a means to show how the air moves. After performing this experiment, the pupils should be able to state the four things needed to start a fire and keep it going. (These are listed on page 155.) The pictures on page 155 give examples of how these four things are used. Have the pupils recall concepts that they have previously learned which help them understand how a fire supplies itself with fresh air. (See pages 113-114 of the text.) See also *Things to Do*, page 175, No. 1.

Questions (Page 155)

1. Combustible material, enough heat to raise the material to its kindling temperature, current of fresh air.
2. Materials with a low kindling temperature as twigs, leaves, or shavings, are laid first so that the fire may be easily started. Materials with higher kindling temperatures are put on top. All materials are arranged so that a current of fresh air can get to the fire.

3. So that air can get through the grate to the fire.

4. Yes. Cold air around it pushes warm air up. This makes a current of air.

5. The space around wood shavings lets air get to them. Sawdust is closely packed, and the air cannot get to it so easily.

6. The pages are close together, and air cannot get to them easily. The best way to burn it would be to open it or tear it apart.

What happens when things burn? (Pages 156-160)

Concepts

1. When any material burns, it gives off heat and light and becomes smaller.
2. When any material burns, a chemical change takes place.
   a) Carbon contained in the material combines with oxygen to form carbon dioxide, a colorless gas.
   b) Hydrogen contained in the material combines with oxygen to form water vapor.
   c) Any minerals in the material are left as ashes.
   d) If there is not enough oxygen to combine with the carbon, some of the carbon is given off as smoke.

Experiments

Pages 157-158: To show that materials need oxygen in order to burn.

Materials: Test tube or small bottle, water, iron filings (or steel wool), pan with low sides, matches.

Page 158: To show what happens when a candle burns.

Materials: Paraffin candle, match, plate.

Page 159: To show that carbon dioxide is formed when a candle burns.

Materials: Limewater, glass, glass tubing or soda straw, candle, piece of wire, match, two glass jars, flat piece of glass.

Page 159: To show that water is formed when a candle burns.

Materials: Candle, match, glass jar.

Procedure

In preparation for this problem, pupils should set up the experiment pictured and described on page 157. After the experiment is set up, ask them to recall what they know about iron rusting. (It is a chemical change in which oxygen combines with iron.)

Before the pupils examine the results of the experiment pictured and described on page 157, ask them to tell everything they now know about what happens when something burns. Have them recall what they learned in the preceding unit. After this discussion, they should read to the last paragraph on page 157 and list the things that happen as a fire burns. Then they are ready to examine the results of the experiment and draw their conclusions.

The next experiment described in the second column on page 158 and illustrated on that page should be done carefully. Be sure that the pupils follow the directions given in the text. The same caution applies to the experiments on page 159. Pupils should understand that limewater is used to test for carbon dioxide, just as blue litmus paper is used to test for acids. The two paragraphs on the top of page 160 summarize the essential learnings.

Questions (Page 160)

1. Produces heat and light; gets smaller; often makes smoke; sometimes disappears or else leaves ash.

2. (Experiment, page 157.) Took the oxygen out of some air; tried to burn a match in this air and then in ordinary air under the same conditions.

3. By burning a candle in a jar, removing the candle and pouring in limewater, which appears milky when carbon dioxide is put into it.

4. By holding a dry jar over a candle, allowing air to enter at the bottom, and seeing the moisture collect on the sides of the jar.

5. Because they are made entirely of elements that will combine with oxygen to form gases. Oil, kerosene, gasoline, gas.

6. Materials that do not combine with oxygen. Paper, cloth, wood, coal.

How can we conserve our fuels? (Pages 160-164)

Concepts

1. We must conserve our coal, oil, and gas, because the supply will not last forever and these fuels cannot be replaced.
2. Fuels may be conserved by using them carefully.
3. Fuels may be conserved by using new kinds of fuels or other sources of energy.

Information for the teacher

Gas from the earth is called *natural gas*. It is really a mixture of four gases: methane, ethane, propane, and butane. The largest part is methane.

In the future, gas may be obtained from coal by burning it under ground. The gas will be piped to the surface, and the various products of coal recovered in large recovery plants. This will enable much coal to be recovered from incompletely worked mines. This method has been successfully used in some places and is now being tried in this country.

To stretch out the oil supply, deeper drilling, better processes for making synthetic fuels, and more efficient use of fuel must be developed.

Material on coal resources and how to use them may be obtained from the Bituminous Coal Institute, 60 E. 42nd Street, New York 17, N. Y.

Procedure

Have the pupils look at the picture on page 161 and give their answer to this question: "What do you think is wrong in this picture?" From the preceding problem, they should know that smoke shows that all of the fuel is not being burned. Then ask pupils how we can conserve fuels. Write the pupils' suggestions on the board and then have them read pages 160-164. The pictures on page 162 and 163 illustrate ways of saving fuel. Ask pupils to find places at home, at school, and in the community where fuel can be saved and to learn whether it is being done. If new building is going on near the school, let the pupils observe insulation as well as the heating plant.

Questions (Page 164)

1. Because the coal, oil, and gas taken from the earth cannot be replaced.
2. (*a*) Keep fires from smoking so that we do not lose fuel in escaping carbon. (*b*) Save heat in buildings so that we use less fuel. (*c*) Save heat in cooking so that fuel is not wasted. (*d*) Whenever possible, use fuels that are being replaced, such as wood. (*e*) Use other sources of energy, such as moving water and electric current.
3. Answer depends on community. If the answer is yes, smoke will probably be the reason.
4. More air should be mixed with the gas, because the fuel is not getting enough oxygen to burn all the carbon.

What can we do to prevent fires? (Pages 164-167)

Concept

Accidental fires can be avoided by preventing the three things needed for burning from coming together.

Information for the teacher

Pictures. Page 165. Put water on it and cover it with dirt or sand.

Page 166. Rags, papers, and other combustible materials should never be piled near a furnace.

Text. The fourth paragraph on page 166 describes what is called *spontaneous combustion*. Spontaneous combustion may also occur in new hay in a barn or grain in a bin. It occurs most easily in materials with low kindling temperatures.

For further material on safety with fire, the teacher should write to the School and

College Division of the National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois, for a list of materials available to elementary teachers.

State conservation bureaus will furnish material on safety with outdoor fires and give any local or regional regulations. Much material is also obtainable from the United States Department of Agriculture (Forest Service). See Bibliography, page 85, for method of obtaining bulletins.

Procedure

The importance of this problem and the next one cannot be overemphasized. Stress the fact that accidental fires can be prevented by using what the pupils have learned about burning. Then have them read and discuss pages 164-167. Be sure that the pupils examine the pictures on pages 165 and 166. Have them answer the questions under the pictures to review what they have learned about fire prevention. The safety rules on page 167 should then be studied, and each individual in the class should decide how he himself can best use them. The rules may be copied and taken home to be used by the whole family.

A fireman from the local department may be willing to talk to the class about preventing fires, as suggested in *Things to Do*, page 175, No. 7. Other interesting activities will be found on the same page, Nos. 3, 4, 8, and 9.

Questions (Page 167)

1. By keeping them from starting.
2. Keep the things needed for burning from coming together.
3. (1) Matches cause many accidental fires. (2) An outdoor fire may start a much bigger fire. (3) The fire may blaze up. (4) They may cause a sudden blaze or explosion. Paper and wood are more easily controlled. (5) They may easily set fire to objects in the room. (6) They may burst into flame and start a fire.
4. Carelessness. If people are careful with fires, there will be few harmful fires.
5. Answers individual.

How can we put out fires? (Pages 168-173)

Concepts

1. A fire should be promptly and correctly reported to the fire department.
2. Fires can be put out by removing one or more of the three things needed for burning.

Experiment

PAGE 172: To see how carbon-dioxide gas puts out a fire.

MATERIALS: Baking soda, vinegar, glass, match.

Information for the teacher

PICTURES. PAGE 168. Most city alarm boxes are operated as shown in the picture, although many are opened by a handle rather than a key.

PAGE 169. Fire lanes are made wide enough so that the fire cannot jump across them unless there is an extremely strong wind.

PAGE 170. The water cools the combustible materials so that they do not burn completely. This causes some of the material to go off as smoke.

PAGE 171. If you know how different kinds of fire extinguishers work, you will be able to use whatever kind is at hand in an emergency. In the picture, the extinguisher labeled "carbon dioxide" is a small tank of carbon-dioxide gas. Carbon tetrachloride is also used as cleaning fluid. The soda-acid extinguisher is the type described in the text (page 172) in which carbon dioxide is formed from soda and acid. A foamite extinguisher is a variation of a carbon-dioxide extinguisher. It produces a foam of carbon-dioxide bubbles. These bubbles float on the gasoline or oil and keep the air away. The foam is made by mixing a solution of baking soda and extract of licorice root with a solution of aluminum sulphate. The carbon dioxide is made by chemical action between soda and aluminum sulphate. The extract of licorice root helps make tough bubbles to carry the carbon dioxide to the fire.

PAGE 172. This is a specially constructed airport fire truck. It contains both liquid carbon dioxide kept at 0°F., which can be expelled as carbon-dioxide snow, and a foam solution. The cooling effect of the snow allows the truck to approach the fire closely and permits rescue work to get under way at once, even before the fire is completely extinguished. The blanketing effect of the foam extinguishes the flame and covers any exposed gasoline that might be ignited.

Procedure

Like the preceding problem, this one should be taught as an application of what the pupils have learned about burning. Have them read and discuss pages 168-173. Be sure that they use the pictures in their discussion. The safety rules should be thoroughly understood. Pupils should be able to give a reason for each rule.

The children should, if possible, become familiar with the different kinds of fire extinguishers in common use. After doing the experiment on page 172, the class should examine one of the school fire extinguishers. The school engineer will probably be willing to show the extinguisher. Or if there is an old one that is no longer used, it can be added to the science equipment. The extinguisher should be opened so that the pupils can see the glass bottle containing the acid and how the heavy stopper falls out when the extinguisher is turned upside down. Since they have seen the action of vinegar, a weak acid, on baking soda, they can understand how the strong acid acting on the soda can produce quantities of carbon dioxide. Pupils should understand why a fire extinguisher should never be taken from the hook unless it is to be used. The chemical action cannot be stopped once it is started.

If possible, have pupils visit a local fire station to examine the fire extinguishers and other equipment that the firemen use, as suggested in *Things to Do*, page 175, No. 2.

After a study of this problem, the pupils may perform a worth-while service for the school by helping other classes realize the importance of observing the rules for fire drills. If no such rules have been made, the class may make a set of rules to fit the school and send them to each room in the building. Such rules might include:

1. Leave your desk and prepare to leave your room at once.
2. Keep in line as directed.
3. If you are among the first in line, go out far enough from the building to allow others to get out without congestion.
4. Do not re-enter the building until a signal is given.

Questions (Page 173)

1. Clear away any material that will burn; cool the burning material; shut off the supply of oxygen.
2. It cools the material below its kindling temperature and shuts off the supply of oxygen.
3. A stream of water will spread fat and oil fires. These fires should be smothered in some way, as with carbon-dioxide gas, sand, or dirt.
4. Stand still and look for something to roll yourself in to shut off the supply of oxygen.
5. Report to the fire department at once. If the fire is small enough, use water to try to put it out, or try to smother the flames.

Questions to answer (Page 174)

PICTURE. No. Never use kerosene or gasoline to help start a fire.

1. So that a fresh supply of oxygen can get to the wood.
2. Both should be open to let air in and smoke and gases out.
3. Turn down the wick so that less fuel is supplied. Or clean and trim the wick so that the fuel can burn more easily.
4. Gas and kerosene are made of elements that all combine with oxygen in the chemical change that takes place when they burn.
5. There is oxygen all around it when it is in the air.
6. The added leaves shut off some of the oxygen and thus prevent burning.
7. Heat from the hot lamp makes them evaporate easily. The vapor mixes with oxygen in the air and may easily explode.

8. By shutting off the supply of oxygen.

9. Answers brought out in discussion of safety rules.

10. The same amount of kindling wood might be laid under the same amount of each kind of coal. The kind that caught fire more quickly would have the lower kindling temperature. Soft coal usually has the lower kindling temperature.

11. They should be opened to let in as much oxygen as possible.

12. Prevent or help prevent needless fires. Conserve fuel when cooking, heating, etc.

13. Chimneys provide a better draft for the fire. The air moves by the fire more rapidly, and so the fire gets more oxygen. They also let smoke from our stoves and furnaces escape. They carry the sparks high above the roof so that the sparks have gone out before they fall on the roof.

14. You could use water, sand or dirt, rugs or blankets, or whatever was available to smother the flames. An oil fire could be put out with sand or dirt and blazing fat with soda or by covering it with a metal cover.

Things to do (Page 175)

1. Use the picture on page 150 as a guide.

2. This visit should be planned in advance by the teacher.

3. Interviews with local fire-insurance companies, or letters to them, will bring additional information.

4. Inquiries may be made at lumber companies and other agencies for building materials. Most common are the non-combustible shingles of various kinds. Slate and tile roofs are, of course, made of materials naturally non-combustible. These are better than wooden shingles because they prevent the house from being set on fire by flying sparks from other fires, defective chimneys, etc.

5. The most common matches will be safety matches and the large kitchen matches. Someone may have some of the matches with wax sticks such as used in Mexico.

6. Consult local fuel dealers.

7-8. Individual or group activities.

9. See "Information for the teacher," column 2, page 62 of this *Guidebook*.

UNIT 7. *Why Do You Need Food?*

Purpose and scope

This unit and the two units that follow all deal in some way with food. Unit 7 takes up the different kinds of foods and their uses in the body. Unit 8 discusses the sources of food. Unit 9 tells how to make and care for a garden that will produce food. The sequence of units thus insures an orderly development of fundamental understandings by beginning with food problems of immediate concern to the pupils.

If this unit is made real to pupils, they will understand the importance of eating the proper food. They should be urged to apply the things that they learn to their own living. If there is a school lunch program, or a school cafeteria, pupils can apply what they are learning to the selection of food. The adults responsible for planning of the school lunches may have much valuable information to contribute to the class.

Science background

Look and Learn: Unit 1, Animals; Unit 4, Outdoors.

All Around Us: Unit 1, Animals.

How Do We Know?: Unit 1, Animals.

Discovering Our World, Book One: Unit 2, Why Do All Living Things Need Air and

Water? Unit 3, How Does Your Body Work? Unit 7, How Can You Keep Well? Unit 8, How Do Animals and Plants Grow?

Discovering Our World, Book Two: Unit 2, What Makes Things Move? Unit 5, What Are Things Made Of? Unit 6, How Can We Control Fire?

General concepts

1. The right kinds and amounts of food are necessary for proper growth and development of your body.
2. Fats and carbohydrates supply your body with energy and heat.
3. Proteins and minerals help your body grow properly and repair worn-out parts.
4. Vitamins protect your body from certain diseases and help it grow properly.
5. Your body needs plenty of water to keep it well.
6. The proper amounts of the necessary foods can be obtained by planning or choosing well-balanced diets.
7. Food should be cooked properly.

Introducing the unit (Page 177)

Write the unit title on the board and then ask the pupils to give as many reasons as they can why they need food. List the reasons on the board under the unit title. Keep the list so that it can be checked and revised as the study of the unit progresses.

Now have the pupils read and discuss page 177. After the discussion, let them try to decide why the animals pictured on pages 176-177 need careful feeding.

What does food do for you? (Pages 178-180)

Concepts

The right kinds and amounts of food are necessary for proper growth and development of your body.

- *a*) Some foods make you grow bigger and taller.
- *b*) Some foods help prevent diseases.
- *c*) Some foods help make healthy teeth and bones.
- *d*) Some foods give you energy.
- *e*) Some foods help repair worn-out parts of your body and make some of the materials that keep it running well.

Experiment

PAGE 180: To find out what foods help rats grow and keep healthy.

MATERIALS: White rats (at least four, the same age and size), lean meat, bread, potatoes, water, raw and cooked vegetables, milk, cages for the rats, scales.

Information for the teacher

PICTURES. PAGE 178. The practice of weighing and measuring pupils is carried on regularly in many schools. A very helpful pamphlet for this problem and for the unit as a whole is published by the United States Office of Education. It is Pamphlet No. 1 of the Nutrition Education Series—"Nutrition Education in the Elementary Schools." (See Bibliography for method of obtaining it.) It gives help in planning nutrition activities as well as giving the basic information needed for children at this level. The pamphlet stresses the importance of giving the children a true idea of growth. It states: "Growth depends on many closely related factors; it is impossible to specify exactly which factor is responsible for any child's failure to grow as rapidly as he desires.

"The teacher should make clear that the rate of growth depends partly on body build and other hereditary factors and partly on adequate rest, freedom from infection, and adequate food. The addition of any one kind of food to the diet may not produce immediate or marked results, especially if some other conditions favorable to growth are lacking.

"The practice of designating children as overweight, normal, or underweight has been abandoned in most schools because it is often seriously misleading. What a child should weigh is determined largely by his individual physical build. If he fails to grow over a period of four or five months, or if he appears unduly thin or unduly fat, medical advice should be sought. It is important to recognize that being 'normal' in weight does not necessarily mean that a child is well-nourished."

Page 180. For the rat experiment, other diets than the ones given in the text are suggested in the pamphlet mentioned above. These diets show the effects of other kinds of foods. This experiment can be very helpful if it is carefully done. It is best to have at least two animals in each cage, although if both are of the same sex, one may be used in each cage. If the animals are of mixed sexes, one female and one male should be placed in each cage. Arrangements must be made so that the animals are properly fed over the weekend, or the results will not be accurate.

This experiment will be more successful if the rats on the good diet take in as much milk as they will, about three tablespoonfuls each day, before they are given water. Rats will not drink milk if water is available. For this reason, dried milk is often mixed with the other solid foods, instead of giving liquid milk. A weekly record is kept of the gains of each animal, and other signs of good or poor nutrition are noted. If possible, after a marked difference has developed between the rats in the two cages, the rats on the poorer diet should be changed to the better diet and the results observed over a period of weeks.

Text. Page 179. Paragraph 1 refers to the work on *pellagra* by Dr. Joseph Goldberger. He discovered that pellagra is caused by diets lacking in milk, eggs, green vegetables, etc. These foods all contain one of the B vitamins.

Many organizations provide free or low-cost materials on nutrition for teachers. See Bibliography for sources of materials that will give additional help for all parts of this unit.

Procedure

From previous units, the pupils already know that food provides energy. This problem may be introduced by having the pupils discuss what they already know about food. Then have the pupils read pages 178-179 to find out as many ways as possible in which foods help the body.

The food list suggested on page 180 will be very useful as the study of the unit progresses. Let the pupils plan how this list is to be kept.

The rat-feeding experiment on page 180 is a most interesting and instructive part of this unit. It provides an excellent opportunity for exercising care in experimenting, for careful keeping of data, and for drawing accurate conclusions. If the rats are available, ask the pupils if they can decide how to set up an experiment with the rats so that they can learn how important it is to eat the proper kind of food. After they have discussed this question, let them read page 180 and set up the experiment.

Questions (Page 180)

1. Makes you grow bigger; helps you grow strong, healthy teeth and a healthy body; gives you strength to do work and keep warm; makes new blood and skin, etc.
2. Food supplies the energy that keeps you warm and keeps your heart pumping and your lungs moving while you are asleep.
3. Rats that have a good diet grow more and look healthier than rats that have a poor diet.

What foods keep you warm and give you energy? (Pages 181-185)

Concepts

Fats and carbohydrates supply your body with energy and heat.

a) Butter, lard, margarine, etc., contain fats.

b) Starch and sugar are carbohydrates.

c) Fats and carbohydrates are compounds made of carbon, hydrogen, and oxygen.

Experiments

Page 183: To test some foods for fat.

Materials: Food containing fats and some other foods, paper.

Page 184: To learn the test for starch and to test some foods for starch.

Materials: Two glasses of water, starch, iodine, knife, potato, cereals, bread, different fruits and vegetables, corn seed, bean seed.

Information for the teacher

Pictures. Page 182. The foods are walnuts, oil, cream, butter, lard, bacon.

Page 183. The foods are honey, bread, sugar, macaroni, beans, oatmeal, potato.

Page 184. Cut the squash, eggplant, onion, corn kernels, and string beans. Put a few drops of iodine on each one. The foods having starch (potato, corn) will turn dark blue, purple, or black.

Procedure

Pupils should look at their lists and try to decide which foods keep them warm and provide energy. Then have the pupils read down to the last paragraph on page 182. Ask them to tell what food materials are called fuel foods or energy foods (fats and carbohydrates). Pronounce the word *carbohydrate* for the class if necessary or have the pupils refer to *Science Words* for the pronunciation. The children should then test different foods for fat, as suggested in the paragraph that begins at bottom of page 182. Have the pupils identify the foods in the picture on page 182. Then read and discuss the next two paragraphs on page 183.

Now the children are ready to learn about carbohydrates. Have them read the next to last paragraph on page 183 and identify the foods in the picture at the top of the page. Then the pupils should read the next paragraph and do the experiment described and illustrated on page 184.

Pupils will be interested in making the tests for different food materials. Everyone in the class should have an opportunity to observe the tests. (No test for sugar is given in the text, since tests for sugar are too difficult for pupils at this grade level.)

After the rest of the problem has been read and discussed, pupils should decide which of the foods in their lists contain fats and which contain starchy carbohydrates. Also, they should decide the same thing for the foods used in the rat diets. Pupils may wish to make a series of wall charts on which they can place pictures of fat foods and carbohydrate foods.

The last paragraph on page 185 can be related to what the children have learned about the diet of peoples that live in cold climates.

Questions (Page 185)

1. Fat or carbohydrate. It supplies us with heat to keep us warm and energy to move our muscles.
2. Food combines with oxygen in your body to produce heat and energy.
3. Energy is used by your muscles to do their work, and it provides the heat to keep your body warm.
4. Butter, lard, margarine, meat, egg yolk, cheese, nuts, etc. Answers will vary.
5. Fruit (oranges, bananas, grapes, apples, berries), candy, bread, potatoes, cereals, etc. Answers will vary.

What foods help you grow and keep healthy? (Pages 185-188)

Concepts

Proteins and minerals help your body grow properly and repair worn-out parts.

a) Lean meat, milk, cheese, eggs, fish, and a few vegetables contain much protein.

b) Milk, egg yolk, cheese, liver, lean meat, fish, seafoods, and some vegetables contain necessary minerals.

c) Protein is a compound of carbon, hydrogen, oxygen, nitrogen, and sometimes sulphur and phosphorus.

d) Calcium, phosphorus, iron, and iodine are necessary minerals.

Experiment

Page 187: To show that bones need calcium to make them stiff.

Materials: Slender chicken bone, dish, strong vinegar.

Information for the teacher

Pictures. Page 186. The foods are chicken, milk, cheese, beef, eggs, fish, beans, liver.

Page 187. The foods are cheese, milk, celery, liver, peas, tomatoes, spinach, carrots, oranges, apples. (Some water is a good source of minerals.)

Procedure

The same general procedure used in the preceding problem may be used here. Have the pupils read to the end of the first paragraph on page 186. Pronounce the word *protein* or have the pupils find its pronunciation in *Science Words*. Then let them identify the foods that contain protein in the picture on page 186.

Then let the pupils do the experiment described on page 187 and read to the end of the problem. They should identify the food in the picture on page 187. Now have the pupils use the pictures to find foods that provide both protein and minerals (milk, cheese, liver). Let them make a list of foods that are good sources of both kinds of body-building foods. Also have the pupils apply what they have learned to the diets in the rat experiments.

Questions (Page 188)

1. Protein, minerals.
2. Lean meat, milk, cheese, eggs, fish, beans.
3. You need minerals such as calcium and phosphorus for your bones and teeth, and iron for your blood.
4. Protein contains the elements carbon, oxygen, hydrogen, and nitrogen, and sometimes sulphur and phosphorus, while fats and carbohydrates do not contain the last three elements. Protein is a body-building food, while fats and carbohydrates are fuel foods or energy foods.

How do vitamins help you keep well? (Pages 188-192)

Concepts

1. Vitamins protect your body from certain diseases and help it grow properly.
2. A well-balanced diet containing the protective foods usually provides the necessary amounts of vitamins for your body.

Information for the teacher

Pictures. Page 189. Dr. Eijkman and his chicken experiment.

Page 190. The foods are oranges, apples, enriched bread, yeast, milk, eggs, cereal, butter, spinach, cod-liver oil, carrots, liver, tomatoes, peas.

Page 191. Bakers can buy tablets containing specified amounts of vitamin B_1 and the other B vitamins. These tablets are dissolved in water and put into the dough. The government has set up standards for enrichment. When a bread label says that the bread has been enriched, it means that at least a specified amount of vitamin B_1, riboflavin, niacin, and iron has been added.

Page 192. The prevention of rickets by vitamin D. These rats are from the same litter, twenty weeks old. The top picture shows the short body and bowlegs typical of rickets.

Text. The story of the discovery of the cause of beriberi is about Dr. Christian Eijkman, a Dutch physician who was the medical officer at a prison in the Dutch East Indies. He made his important discovery in 1897. Later the substance in the rice hulls was called Vitamin B by Dr. Casimir Funk, a Polish scientist, who named the vitamins in 1921. Still later, an American scientist, Dr. R. R. Williams, discovered that this substance is one of the several vitamins that make up vitamin B or the vitamin-B complex, as it is usually called. He found that it is the chemical substance *thiamine*, now known as vitamin B_1. Two of the other members of the vitamin-B complex are *niacin*, the factor controlling pellagra (mentioned on page 67 of this *Guidebook*) and *riboflavin*, which controls another disease that accompanies pellagra.

Vitamin A was the first vitamin to be identified individually. This was accomplished by Dr. E. V. McCollum and Marguerite Davis in 1915. Vitamin A is manufactured in the animal body from carotene, a substance occurring in such plant parts as green leaves and carrot roots. When vitamin A is added to margarine, the margarine is said to be "fortified."

Vitamin C is known as the antiscorbutic vitamin. It is the chemical substance ascorbic acid. The discoverer of the beneficial results of drinking citrus juice was Dr. Lind, a surgeon in the British navy in the early eighteenth century. This good effect had been noted before, but Dr. Lind was the first to use the experimental method of demonstrating the fact.

Vitamin D, called the antirachitic vitamin, is now being obtained from shark livers as well as from cod and halibut livers. When food is "irradiated by ultraviolet light," the substance ergosterol in the food is changed to vitamin D.

Procedure

Since practically all pupils have some information about vitamins, a good way to introduce the unit is to have them tell their experiences. Then let them read and discuss pages 188-189 (except the last paragraph). The story of the doctor's experiment with chickens illustrated on page 189 is an excellent example of how scientists work.

Now have the pupils read and discuss the rest of the problem, using the pictures on pages 190-192. Let them identify the foods in the picture on page 190. They should observe that these foods also supply fats, carbohydrates, proteins, or minerals as well as vitamins.

A chart summarizing the information about each vitamin discussed in the text should be made. Pupils may also wish to bring empty containers for vitamins from home and make an exhibit of them.

Questions (Page 192)

1. A food that contains vitamins.

2-3. *Vitamin A:* important to eyes, to skin inside mouth and throat; keeps you growing well. Butter, margarine, carrots, tomatoes.

Vitamin B_1*:* helps you grow; gives you appetite. Whole wheat, milk, cheese, liver, spinach.

Vitamin C: prevents scurvy; helps your body heal; helps your body use calcium. Oranges, lemons, grapefruit, tomatoes, and other fruits and vegetables.

Vitamin D: makes your bones grow straight and strong; helps your teeth; prevents rickets. Fish, liver, egg yolks, and sunshine.

4. They help us know what foods to eat to keep our bodies in the healthiest possible condition.

5. No. You may not need them, and they may do your body more harm than good.

What does water do for your body? (Page 193)

Concepts

Your body needs plenty of water to keep well.

a) Water makes up a large part of your blood.

b) Water helps keep your body at the right temperature.

c) Water helps dissolve the food that is taken into your body.

d) Water helps carry off waste materials from your body.

Information for the teacher

Pictures. Page 193. The pictures show how much water is obtained from fresh potatoes, raspberries, and string beans when these foods are dried.

Procedure

Have the pupils discuss the pictures on page 193 before reading the page. Pupils should apply what they learn to their own diets and to the rat experiment. For an additional activity, see *Things to Do*, page 203, No. 5.

What habits will help you get the proper foods? (Pages 194-199)

Concept

The proper amounts of the necessary foods can be obtained by planning or choosing well-balanced diets.

Experiment

Page 195: To separate the different materials in milk.

Materials: Bottle of milk (quart), spoon, glass jar, egg beater, container for skim milk, strainer, salt, shallow dish, source of heat.

Information for the teacher

Pictures. Page 194. Recommended daily servings of each group are: *1* and 2, one or more; *3*, two or more; *4*, one quart for children (ice cream may be included in this group); *5*, one to two daily or one daily plus four eggs a week (soybeans included here and in *6*); *6* and *7*, some daily.

Page 197. The girl is eating a well-balanced luncheon, made up of foods from five groups.

Page 198. The lines, or growth curves, on the graph show that the rats have increased in weight steadily over a period of weeks. Those on a good diet have increased much more in weight than those on a poor diet. One of the rats on a good diet has increased more than the other. This indicates that some other factor may be entering into their growth.

If the rat experiment was carried out carefully with these diets, the children should obtain similar growth curves on their graphs. Other physical differences that might be noted are: Good diet—fur sleek and shiny, eyes shiny, ears and noses pink, calm and friendly; poor diet—fur rough and ragged, eyes dull, nervous and irritable.

Text. In discussing diets and eating habits, the teacher must use tact with regard to the practices followed in the children's homes. A knowledge of the backgrounds of her pupils will help in discussing the diet lists kept by the children, since she will, of course, wish to avoid any embarrassments that might arise because of economic conditions or special food customs.

Procedure

Pupils are now ready to understand the "why" of the chart given on page 194. They can tell in each case what a particular food does for the body. Begin the problem with a discussion based on the chart and then have the pupils read page 194 and the first paragraph on page 195.

Next they should do the experiment and refer to the picture on page 195. The pupils should then read down to the last paragraph on page 196 and discuss the picture.

An examination of the list of foods that have been kept is suggested on page 196. Each pupil should analyze his list and try to decide whether he is getting the proper variety of foods. Pupils should be urged to discuss their findings at home. Have the children read and discuss the rest of the problem, using the picture on page 197.

The basic outcome of this problem depends on how well the pupils translate what they have learned into action. A set of rules to observe in building good food habits may be made as the result of having studied this problem. However, these rules are valuable only if the pupils follow them after the unit is finished.

The summarizing of the rat experiment (page 199) is very important. Pupils should be urged to make their conclusions as scientific as possible. The graph on page 198 will be very useful in helping pupils check their own findings. For additional activities, see *Things to Do*, page 203, Nos. 1-4, 6, and 7.

Questions (Page 199)

1. Make a chart to show what foods you should have and then eat something from each group every day. Talk with your mother or teacher about what you are eating to make sure that you are getting the right foods. Do not spoil your appetite for the proper foods by drinking pop and eating candy between meals.

2. Your body needs them for growth and health. Answers for the second and third parts will vary.

3. Eat something from each group of foods listed in the chart on page 194.

4. Milk has fat, protein, carbohydrate, and minerals in it, all of which your body needs.

5. *Eggs* contain fat, protein, minerals, vitamins. *Candy* is a fuel food but should not be substituted for other food. *Whole-wheat bread* is rich in vitamin B, which is body-building and gives you an appetite. *Soup* made with milk gives you some of the milk you need and is good on a cold day. *Vegetables* supply minerals and vitamins; they should be eaten daily.

What does cooking do for your food? (Pages 199-202)

Concepts

1. Food is cooked to make it easier to digest and to destroy germs.
2. Food should be cooked in a way that will preserve the vitamins and minerals.

Information for the teacher

TEXT. None of the important substances in milk are substantially affected by pasteurization, except for the loss of some vitamin B_1 and vitamin C. Other foods in the diet usually make up for this loss. Home pasteurization is not a difficult process. It should be encouraged where commercially pasteurized milk is not available.

Procedure

The final problem of this unit gives reasons for cooking food and tells how to cook foods properly. To introduce the problem, have pupils read the title and then tell what they think that cooking does for food. After the discussion, let the pupils read the problem and use the pictures on pages 200-201 as a summary. The problem will be made more real if pupils can actually observe food preparation in a domestic science class or in the school cafeteria.

Questions (Page 202)

1. To make it more easily digested; to kill germs; to give a better taste to the food.
2. (*a*) Using a small amount of water so that fewer vitamins and minerals dissolve. (*b*) Using water from vegetables because it contains vitamins and minerals. (*c*) Using beet greens because they contain many vitamins. (*d*) Cooking potatoes with skins on, because most of the minerals are right under the skin; when the potatoes are peeled, these minerals are lost. (*e*) Cooking vegetables in covered pans, because air destroys many of the vitamins. (*f*) Keeping vegetables cool, because heat destroys some vitamins.
3. It kills any germs that may be in it. Milk is heated to 145° F. and kept at that temperature for half an hour.

Questions to answer (Page 202)

PICTURE. Sandwiches can be made of eggs, peanut butter, or cheese. A covered jar in the lunch box might contain a salad of carrots, tomatoes, green and leafy vegetables, etc. Milk, cocoa made with milk, or tomato juice should be chosen rather than coffee or pop. Fruit should be chosen for dessert; cake added only after eating the basic seven.

1. Fewer vitamins are destroyed in canning than in cooking. Canning keeps out the air.
2. They will help you grow and be healthy when you understand the needs of your body.
3. Scientists find out what foods we need and what each food does for us.
4. You need food to help your body grow and keep healthy.
5. So that their animals will be fat and healthy and worth more money.

Things to do (Page 203)

1-3. Individual or group activity.

4. Consult elementary encyclopedias.
5. Weigh fruits and vegetables and then dry them slowly in hot air or in the sun until they shrivel and shrink. Weigh them again and see how much weight they have lost.
6. Class activity.
7. If people eat the proper foods, they not only grow properly but are kept from getting certain diseases. It is better to prevent illness than to have to cure it after it occurs.
8. Individual or group activity. Other food containers may be used.

UNIT 8. *Where Does All the Food of the World Come From?*

Purpose and scope

In the previous unit, pupils learned why they need food. This unit helps them to become acquainted with the source of their food. They learn to appreciate the fact that within the green leaf all of the food in the world is made. They already know that plants need air, water, sunlight, and a proper growing temperature. Now they will learn some of the things that take place inside the green leaf as it makes food.

A proper understanding of this unit is essential for the unit on gardening that concludes this book. The unit also provides valuable background material for *Discovering Our World, Book Three*, Unit 9, Where Do New Plants and Animals Come From?

Science background

Look and Learn: Unit 1, Animals; Unit 4, Outdoors

All Around Us: Unit 1, Animals; Unit 4, Plants

How Do We Know?: Unit 1, Animals; Unit 3, Plants

Discovering Our World, Book One: Unit 1, How Are All the Things of the World Put in Groups? Unit 2, Why Do All Living Things Need Air and Water? Unit 7, How Do You Keep Well? Unit 8, How Do Animals and Plants Grow?

Discovering Our World, Book Two: Unit 1, How Do Living Things Help and Harm Each Other? Unit 5, What Are Things Made Of? Unit 7, Why Do You Need Food?

General concepts

1. All the food in the world comes from green plants.
2. Green plants get food materials from the soil through their roots.
3. Green plants need water and minerals from the soil and carbon dioxide from the air to make food.
4. To make food, plants must have a green material called chlorophyll.
5. Green plants must have sunlight to make chlorophyll.
6. By means of a chemical change, a green leaf makes sugar from carbon dioxide in the air and water from the soil.
7. The chemical change takes place in the cells of the leaf.
8. Green plants make starch, fats, and proteins as well as sugar.
9. The food made by a green plant is dissolved in the sap and carried to all parts of the plant.
10. Plants that do not have chlorophyll cannot make food; they use foods that have already been made by green plants.

Introducing the unit (Pages 205-206)

PICTURES. PAGE 204. Harvesting wheat.

PAGE 205. The picture illustrates the so-called food chain. The small fish at the left is feeding on a green plant. The larger fish that is just appearing eats the small fish. Finally, the otter catches, kills, and eats the larger fish.

Procedure

One way to introduce this unit is to list on the board the kinds of food studied in the previous unit and then ask the pupils to try to decide where these kinds of food come from. After the discussion, have the pupils read the introduction on pages 205-206. Ask them to explain what the picture on page 205 shows.

Another way to introduce the unit is to have each pupil make a list of the foods that he had for breakfast or lunch. Write these things on the board. Now ask the pupils to name the things on the board that came from plants. The first things named will probably be those that obviously come from plants, such as fruits, vegetables, and cereals. At the pupils' direction, cross these off the list on the board.

The things that remain in the list will probably be foods such as milk, cheese, meat, and so forth. Ask the pupils where these foods come from. For example, cheese is made from milk; milk comes from cows; cows eat hay and grain, which come from plants. At this point, some pupil will probably say that you should cross milk, cheese, meat, etc., off the list, too, because they really come from plants. (If no pupil says this, use questions to draw it out.)

In this way, proceed until all the things in the list (except water and salt, if they were mentioned) have been crossed off. The class is now ready to make this conclusion: "Our food comes from plants or from animals that eat plants. So all the food in the world really comes from plants." Pupils can then read the introduction to check their conclusion.

How do roots help plants get food materials? (Pages 206-208)

Concepts

Green plants get food materials from the soil through their roots.

a) Plants have different kinds of roots.

b) Water and dissolved minerals get into the roots through root hairs.

Observations

Page 206: To observe different kinds of roots.

Materials: Various plants with roots intact.

Pages 207-208: To observe root hairs.

Materials: Dozen lima beans or several radish seeds, moist blotting paper, shallow dish, glass cover, magnifying glass.

Information for the teacher

Pictures. Page 206. Sugar-beet root. The main root, which tapers, may go down into the soil to a depth of seven feet. This long main root, together with the large number of lateral roots that come from it, makes the moisture in a large area available to the plant.

Page 207. The young corn plant has a main root. This soon dies, giving place to an extensive system of lateral roots. They usually extend about three feet laterally and seven to seven and one-half feet down. Later, so-called prop roots develop. They can be seen in the picture, growing from the stem just above the board. These roots give additional support.

Page 208. Root hairs grow from the outermost cells of the root back of where the root is adding new cells and elongating. Since root hairs dry up very quickly, plants grown for studying root hairs must be kept moist.

Text. The type of root system that a plant has is a constant characteristic; but the extent may vary with amount of moisture, thickness of stand, and other environmental conditions. Thus, the lateral extent of roots will be much greater when the plants are not crowded. When plants are crowded, the roots of individual plants will turn and grow downward when they come to another plant. Moisture affects the growth, too. Where there is much rainfall and the rain sinks down deep in the soil, the roots extend farther down. Where there is very little rainfall or seasonal moisture, the roots spread out laterally through the upper layers of soil where the moisture is.

Procedure

Ask the pupils to bring to class roots of various plants, such as grass, dandelion, garden vegetable, etc. Also have the pupils start the observation with the seeds described on page 207 so that the roots may be observed later.

Let the pupils examine the roots of the plants that they have brought and also the root hairs of the sprouted seeds. After the observations have been made, have the pupils study pages 206-208, look at the pictures, and discuss their reading and observations. Then observe the root hairs again to summarize. See also *Things to Do*, page 219, Nos. 1 and 6.

Questions (Page 208)

1. Until they dissolve, they cannot get into the root hairs.
2. The root hairs.
3. The plant will die from lack of water.

How do water and air get into the leaves? (Pages 209-211)

Concepts

1. Green plants need water and minerals from the soil and one of the gases from the air to make food.
    a) Water and dissolved minerals get from the roots to the leaves through tubes in the stems and leaves.
    b) Air gets into the plant through tiny openings in the leaves.
2. To make food, plants must have a green material called *chlorophyll.*

Experiment

PAGE 209: To see how water travels up the stem of a plant.

MATERIALS: Stalk of celery with several leaves, knife, glass of water, red ink.

Information for the teacher

PICTURES. PAGE 209. The "strings" are the fibrovascular bundles of the stem. These are really groups of cells consisting of fibers that strengthen the stem, as well as the cells through which water and other materials are carried. As the picture indicates, the bundles are buried in the stem so that in an older celery stalk, the red may not be visible from the outside of the stalk. Cutting a cross section or breaking the stem will reveal these bundles.

PAGE 210. The tiny openings shown in the picture on the left are called *stomata* (singular *stoma*), or breathing pores. They are located in the outermost layer, or epidermis, of the leaf. The two cells surrounding the opening are called the guard cells. These cells cause the stomata to open and close by becoming more or less turgid. In the epidermis of the leaf, the guard cells of the stomata are the only cells that contain chlorophyll. This is further shown in the diagram on page 213.

Stomata are exceedingly small, very much smaller than the hole made by punching the finest sewing needle through a piece of paper. But the tremendous number of them compensates for their small size. There may be more than 60,000 to a square inch on the average leaf. Most of the stomata are usually on the lower surface of the leaf; but in some plants they are on both surfaces. In water plants whose leaves float on the water, the stomata are on the upper surface only.

The skeleton of a leaf such as the one on the right is made by the fibrovascular bundles of the leaf. They carry water and foods and support the leaf.

Procedure

Have the pupils perform the experiment described and pictured on page 209. After a short time, the celery stalk should look very much like the one in the picture at the top of the page. The lower picture shows the tubes in the celery stalk. Let the pupils examine the celery stalk and draw their own conclusion about how water gets into the leaves. The pupils should now read the last two paragraphs on page 209 and find the veins in the leaf pictured at the right on page 210.

Now let the children study the first two paragraphs on page 210 and examine the picture at the left. Pronounce the word *chlorophyll* or have the pupils find its pronunciation in *Science Words*. Be sure that the pupils understand that "green plants" mean plants that have chlorophyll.

The five statements at the end of the problem summarize what the children should now know. For an additional activity, see *Things to Do*, page 219, No. 2.

Questions (Page 211)

1. Water and minerals from the soil, one of the gases in the air.

2. Through root hairs into tubes in the roots and then into tubes in the stem, up these tubes to a leaf, and through veins in the leaf.

3. Through tiny openings in the leaf.

4. The liquid was only in the tubes.

5. To carry water and minerals to the leaves.

6. By leaving the stems in green water for a while.

How does a green leaf make food? (Pages 211-214)

Concepts

1. Green plants must have sunlight to make chlorophyll.
2. By means of a chemical change, a green leaf makes sugar from carbon dioxide in the air and water in the soil.
3. The chemical change takes place in the cells of the leaf.
4. Green plants make starch, fats, and proteins as well as sugar.

Experiment

PAGE 212: To show that plants need sunlight to make chlorophyll.

MATERIALS: Two plants about the same size.

Information for the teacher

PICTURES. PAGE 212. The plants on the right show the typical growth reaction to lack of sunlight. They grow long and straggly, too weak to stand erect, and lack green color. These plants are living off food stored in the cotyledons. They cannot make their own food, so will die as soon as the stored food is gone.

PAGE 213. The picture on the left shows the veins, or fibrovascular bundles, as they appear when the leaf is cut across. On the right is part of the cut end greatly magnified to show the cells that make up the upper and lower epidermis (outermost layers), the bundles, and the chlorophyll-bearing cells of the leaf.

TEXT. The process described in this problem is called *photosynthesis*. It is a complicated process involving a series of chemical changes as yet incompletely understood by scientists. Only the basic ideas are presented here. No distinction is made between the various types of sugar made by plants, such as grape sugar, sugar from sugar beets, from sugar cane, etc.

Procedure

Have the pupils start the experiment described and pictured on page 212 at least a week before this problem is introduced. As an introduction to the problem, let the pupils read and discuss the three paragraphs on page 211. Recall the experiment with sugar (pages 130-131) and, if necessary, repeat the experiment. Then have the class observe the results of the experiment on page 212 and draw conclusions.

The pupils are now ready to read and discuss the rest of the problem, using the pictures on page 213. The first paragraph on page 213 introduces the concept of cells, which is basic to an understanding of all living things. No attempt should be made at this time to extend the concept beyond its immediate application.

Questions (Page 214)

1. Sugar is being made from carbon dioxide and water and then changed to other foods.

2. *Water* supplies hydrogen and oxygen for making sugar and carries dissolved minerals. *Sunlight* enables the chemical change that makes sugar to take place. *Veins* carry water from the stem through the leaves. *Tubes in the stem* carry water from the roots to the leaves. *Air* supplies carbon dioxide for making sugar.

3. When carbon dioxide and water combine to make sugar, a new material is made.

4. It does not get enough sunlight to make chlorophyll.

5. Fungus on page 24 or page 28. It has no chlorophyll.

What becomes of the food made by a green leaf? (Pages 214-216)

Concepts

The food made by a green plant is dissolved in the sap and carried to all parts of the plant.

a) Some of the food is used for growing and making new parts.

b) Some of the food is stored in roots, stems, and seeds and used later.

Information for the teacher

Picture. Page 214. The sap for making maple sugar is collected in the late winter or early spring. After it has been collected, it is put into large iron kettles and boiled steadily for several days. Water and a scum that forms on the top are skimmed off until finally only the sugar is left. It is made into cakes, which harden at once. *Travel Magazine*, March 1946, and *Natural History Magazine*, March 1946, have interesting illustrated accounts of this process.

Procedure

Let the pupils try to answer the question asked in the problem title before reading the text. Have them recall how their bodies use food and how food is carried to all parts of their bodies. The picture on page 214 gives a hint as to the answer.

The diagram on page 215 illustrates the essential ideas in this problem. Let the pupils study the diagram and try to explain what it shows. Then have them read the first three paragraphs to check their explanation. After this, they should read and discuss the rest of the problem. The last two paragraphs on page 216 stress the basic concept underlying the whole unit. Use the concluding question in the last paragraph to clinch the understanding of this concept.

Questions (Page 216)

1. Yes. The other animals eat plants and would starve without them.

2. Answers may include: roots (carrots, beets, etc.); stems (asparagus, white potatoes, etc.); leaves (lettuce, spinach); flowers (cauliflower, broccoli); seeds (beans, peas, etc.).

3. Sap carries it through tubes to all parts of the plant.

4. Food in the plant is changed chemically by the plant to produce wood fibers, and by animals that eat plants to produce milk, meat, and leather.

5. It feeds the new plants inside the seeds when they begin to grow; it is used as food by people and animals.

How do plants that are not green get food? (Pages 216-218)

Concept

Plants that do not have chlorophyll cannot make food; they use food that has already been made by green plants.

Observation

Page 217: To see how molds get food and grow.

Materials: Piece of bread, two dishes, dusty cloth, water.

Information for the teacher

Pictures. Page 217. The typical bread mold, *Rhizopus*. The green mold usually found on lemons and oranges may also appear. The method of obtaining food is the same although the structure of the mold is different.

Page 218. Indian pipes, widely found in damp, rich woods. They are saprophytes; that is, they derive their food from decaying plant and animal matter in the soil.

Page 219. Fairy ring mushrooms.

Procedure

The pupils already have some information about non-green plants from Unit 1, pages 24, 27-28. Let them recall what they already know and then follow the directions for growing mold on page 217. They should read the text to get information about mold itself. Have them contrast green plants with non-green plants with respect to things that each can or cannot do. For additional activities, see *Things to Do*, page 219, Nos. 3 and 4.

Questions (Page 218)

1. Answers may include: fruit, bread, cheese, other foods, wood, leather, etc.

2. Yes. Old materials are destroyed, and new ones are formed.

3. They do not have chlorophyll that makes the chemical change possible. They use food that green plants make and store. Some of the plants are eaten by animals. When the plants and animals die and fall to the ground, mushrooms grow on the decaying plant and animal material in the soil.

Questions to answer (Page 219)

1. No. Water must enter through the roots.
2. If the root hairs are destroyed, the plant will not be able to get water.
3. Plants cannot make food without sunlight, and they make all the food in the world.
4. Answers should include information on pages 211-214.
5. Their energy comes from green plants, which obtained energy from the sun.
6. Several feet away. The root hairs near the ends of the roots take in the water.

Things to do (Page 219)

1. Do not cover the seeds with water or let them dry out. Use a magnifying glass to see the root hairs.
2. If plants are placed in the sunlight, results will be more satisfactory.
3. Individual or group activity. Molds, mushrooms, Indian pipes, etc., may be collected, depending on the location and season.
4. Individual or group activity. Mold or mildew, which is a kind of mold, can be found on food, damp cloth, leather, or other materials, and on plants. (Lilac leaves often show a dusty coating which is mildew.)
5. When leaves spread out so that each leaf can get the maximum amount of light, they are said to be forming a mosaic. Vines on houses and walls often offer excellent examples of this.
6. A thick, central root, such as the sugar beet on page 206, or the carrot, turnip, or dandelion is a taproot.

UNIT 9. *How Can You Make a Garden?*

Purpose and scope

This unit provides an opportunity to learn at first hand how we grow plants for our own use. As previously learned concepts are applied and new information is acquired, pupils come to understand the importance of proper care for growing plants. The problems of the gardener are seen to be much like those of the farmer. From this realization comes a better appreciation of the importance of farming.

Pupils will, of course, derive far more pleasure and profit from the unit if they actually make a garden at school or at home. The activity of making a garden may be carried on by the class as a group or as individuals. As the study of the unit progresses, pupils should apply what they have learned to their gardens. If a garden plot is not available at school or at home, it may be possible for pupils to observe a garden in the community. The teacher may be able to enlist the interest of the owner so that pupils can share in planning a garden even though they cannot plant one. Visits to the garden should then be made as the unit is studied.

Science background

Look and Learn: Unit 4, Outdoors
All Around Us: Unit 4, Plants
How Do We Know?: Unit 3, Plants
Discovering Our World, Book One: Unit 1, How Are the Things of the World Put in

Groups? Unit 2, Why Do All Living Things Need Air and Water? Unit 8, How Do Animals and Plants Grow?

Discovering Our World, Book Two: Unit 1, How Do Living Things Help and Harm Each Other? Unit 8, Where Does All the Food of the World Come From?

General concepts

1. A good garden is carefully planned.
2. Soil must be prepared for planting.
3. Seeds are planted in different ways, depending on the plant to be grown.
4. Growing plants must be given care.
5. Plants must be protected from their enemies.

Introducing the unit (Page 221)

In many classes, there will be some pupils who have made a garden or seen one made. Ask them to tell the class such things as the location of the garden, its size, kinds of plants grown, and care given to the plants. They may also mention some of the tools they used.

Then have the pupils read and discuss page 221. Let them try to decide why each rule is important. It is a good idea to copy the rules on a big piece of paper, as suggested in the last paragraph. A committee may bring seed catalogues and gardening books to school.

How can you plan a garden? (Pages 222-224)

Concepts

A good garden is carefully planned.

a) It should not be too big to take care of properly.

b) It should not produce more than can be used.

c) It should be located in a sunny spot with good soil.

Experiment

PAGES 223-224: To show how different kinds of soil hold water.

MATERIALS: Three lamp chimneys, three pieces of cloth, string, three cups, six glasses, water, sand, clay, loam.

Information for the teacher

Many pamphlets, bulletins, and articles are available to help teachers carry out the projects suggested in this unit. Many states have gardening bulletins that will provide information on local crops and conditions. An excellent bulletin for methods in general, published by the United States Department of Agriculture, is called "Growing Vegetables in Town and City." (See Bibliography for method of obtaining it.) Magazines such as *Better Homes and Gardens*, *American Home*, *Country Gentleman*, and the *Farm Quarterly* should be watched for articles and pictures to illustrate different aspects of gardening and farming.

Procedure

This problem contains the necessary information for planning a garden. Pupils may obtain additional information from seed catalogues and gardening books as suggested in the introduction to the unit. Let the children study and discuss the text down to the experiment on page 223. Then they should perform the experiment and draw their conclusions. The text may then be read to check their results.

After studying the diagrams on page 224 and reading the last paragraph, the pupils should draw plans for their gardens. The plans may then be discussed by the class and revised if necessary.

Questions (Page 224)

1. So you will not start a bigger garden than you can finish; so you will not plant too much of one thing; so that you will choose a sunny spot with good soil.

2. If you start a large garden and cannot take care of it, you will waste time and money; planting too much of one thing also wastes seed, soil, and effort; using good seed on bad

soil wastes the seed because the plants will not grow properly.

3. Look for a place where the sun will shine on it all day and where the soil is mostly loam.

4. If there is water in the soil when you start the experiment, you cannot tell how much of the water in the soil at the end of the experiment came from the glass of water and how much was already there. Also, all three soils must be alike in everything but kind of soil.

5. It holds water better than sand and drains better than clay.

How do we get the soil ready for planting? (Pages 225-228)

Concepts

Soil must be prepared for planting.

a) It must be loosened and broken up so that seeds can be planted and so that moisture will soak in.

b) Poor soil can be improved by making it more like loam.

c) Lime or limestone can be used to make soil less acid.

d) Minerals can be put back in the soil by using fertilizer or rotating crops.

Experiments

PAGE 226: To find out whether soil is acid.

MATERIALS: Moist soil, blue litmus paper.

PAGE 227: To see what happens when fertilizer is used.

MATERIALS: Two flowerpots filled with worn-out soil, seeds, fertilizer.

Information for the teacher

Many different kinds of commercial fertilizer are available. The label tells what the fertilizer contains. So-called all-purpose fertilizer usually has a high percentage of nitrogen, phosphorus, and potassium, elements lacking in most soils.

Clover, alfalfa, soybeans, cowpeas, beans, and peas belong to the group of plants known as legumes. These plants put nitrogen back into the soil because of certain kinds of bacteria that grow in little swellings, or nodules, on their roots. The bacteria (called *nitrogen-fixing*) in these nodules are able to take nitrogen from the air and in some way make it into a form that the plant can use. When the plant dies and decays, this nitrogen is returned to the soil in the form of ammonia or nitrates. Other plants can use the nitrogen in these forms. In this way, nitrogen from the air, which most plants are unable to use, is made available to many plants. Alternating or rotating a leguminous crop with other crops helps keep up the nitrogen supply in the soil. Farmers often inoculate their legume seeds with cultures of the bacteria to insure a good growth of nodules.

Procedure

The experiment on page 227 should be set up and allowed to continue as the study of the unit progresses.

Let the pupils read and discuss the text down to the experiment on page 226. Soil for the experiment can usually be obtained from low, swampy land. After doing the experiment with acid soil, the children should read and discuss the rest of the problem. Have them recall from the preceding unit and earlier science experiments the way in which minerals get into plants (through the roots after dissolving in water in the soil).

Pupils should not be expected to remember what the various elements do for plants. The important idea is that different elements help plants in different ways. Fertilizer and crop rotation help put these elements back in the soil. For additional activities, see *Things to Do*, page 245, Nos. 1 and 9.

Questions (Page 228)

1. It is easier to plant seeds; water soaks into the ground more easily.

2. Mix some clay and humus with it to make it more like loam.

3. To make the soil less acid.

4. All the time that they are growing. When the plants die and decay in the soil.

5. What kind of fertilizer and how much the soil needs.

6. *Alike:* Both grow plants and require similar care. *Different:* Farm is much larger; usually has fewer crops; uses larger machines.

How do we plant a garden? (Pages 229-232)

Concepts

Seeds are planted in different ways, depending on the plant to be grown.

a) They should be planted in straight rows far enough apart so that the plants can be taken care of easily.

b) They should be planted at different depths, depending on the size of the seeds.

c) They should be planted at different times, depending on the kind of seed.

d) Some seeds should be started early in a greenhouse, hotbed, or cold frame; the young plants can then be transplanted to the garden.

Information for the teacher

Transplanting should be done under conditions that will prevent wilting as much as possible. A cloudy day or evening are the best times for transplanting. If the soil is dry, wet the hole thoroughly before putting the plant in. However, care must be taken that the soil is not muddied or it will cake when it is pressed down around the plant.

Procedure

If the pupils are actually making a garden, they should study this problem very carefully to get information about planting it. The pictures show very clearly some of the ways of planting the garden with care. If possible, the pupils should visit a greenhouse, as suggested in *Things to Do*, page 245, No. 2. A hotbed or a cold frame may easily be made by following the directions on page 231 and referring to the picture. An old storm window or other window sash makes a good cover. Every child should, if possible, have the experience of transplanting a young plant. For an additional activity, see *Things to Do*, page 245, No. 4.

Questions (Page 232)

1. No, because the seeds should be planted at different depths.
2. Lettuce, beets. Cucumbers, beans, corn.
3. (*a*) Greenhouse, which is a building with glass walls and roof and heated by the sun or a furnace. When the sun shines, it warms the soil, which warms the air and keeps the plants growing. (*b*) Hotbed, a frame with a glass cover in which are soil and manure. The soil is heated by the sun and by the manure as it decays. (*c*) Cold frame, similar to a hotbed, but without manure.
4. Take up the plant with enough soil around the roots so that you will not injure the root hairs; make a hole in the soil, put in the plant, and pack the soil down firmly.

How do we take care of growing plants? (Pages 233-238)

Concepts

Growing plants must be given care.

a) Plants in rows must be thinned to give each plant plenty of room to get sun, water, and minerals.

b) Trees and other plants can be pruned so that the branches that are left will get more sunlight and water.

c) Cultivating the soil gets rid of weeds, lets air down to the roots of plants, allows water to soak into the soil, and helps keep water from getting out of the soil.

d) The soil must be watered, irrigated, or drained according to whether it is too dry or too wet.

Experiments

PAGES 235-236: To see how cultivating helps keep the soil from drying out.

MATERIALS: Garden soil, flour sieve, two lamp chimneys, flat pan, water.

PAGES 237-238: To show what happens when plants get too much water.

MATERIALS: Two flowerpots just alike with holes in bottoms, small stones, two plants just alike, soil, water, cork to fit hole in pot.

Procedure

This problem gives information essential to the care of growing plants. The pupils should study the text and the pictures carefully for the practical information that they give. If possible, the pupils should also observe an experienced gardener as he trims and prunes plants, weeds, etc.

The experiment on pages 235-236 should be performed and conclusions drawn. The next experiment, pages 237-238, should be set up before the problem is studied so that observations may be made at this time.

If irrigation or dry farming is practiced in the community, a field trip to see how it is done would be valuable. See also *Things to Do*, page 245, No. 7.

Questions (Page 238)

1. If they are too close together, none can get enough sunlight, water, and minerals.
2. You will get bigger tomatoes. Pinch off the little shoots, or suckers, that grow out where the big leaves come from the stem.
3. Sunlight, water, minerals, and oxygen. By planting in a sunny place, thinning, watering, fertilizing, and cultivating.
4. To get rid of weeds that keep plants from getting enough sunlight, water, and minerals. To let air down to the roots so that plants can get oxygen. To let water into the soil and keep it there so that plants can get water.
5. When the soil is too full of water, air cannot get to the roots. The roots rot, and the plants die.
6. By using ditches or tile to carry off the water.

How are plants protected from their enemies? (Pages 239-244)

Concepts

Plants must be protected from their enemies.

a) Weeds can be destroyed by pulling them up, by destroying their seeds, cultivating the soil, or using chemicals.

b) Birds are protectors of plants, because they eat weed seeds and harmful insects.

c) Insect pests can be killed by different poisons, depending on how they eat.

d) Plants must be protected from certain fungi that give them diseases.

Observations

Page 241: To see how a sucking insect eats.
Materials: Plant with aphids on it, magnifying glass.

Information for the teacher

Pictures. Page 239. These weeds may have different common names in different localities. Some of the alternative names are:

Crab grass: Finger grass, Crowfoot grass, Pigeon grass, Polish millet.

Field sorrel: Sheep sorrel, Red sorrel, Sour weed, Cow-sorrel, Horse sorrel.

Plantain: Common plantain, Birdseed plantain, Broadleaf plantain, Dooryard plantain, Greater plantain, Roundleaf plantain.

Purslane: Pursley, Pussley, Purslain.

Quack grass: Couch grass, Witch grass, Wheat grass, Knot grass, Skutch grass.

Shepherd's purse: English shepherd's bag, Lady's purse, Rattle pouches, Case weed, Pepper-and-salt, Blind weed.

Page 240. Weed and insect-destroying birds.

Bobwhite quail: Called quail in the north and partridge in the south. It eats insects when young and weed seeds when adult.

Eastern goldfinch: Also called Yellow bird, Thistle bird, Wild canary, Catnip bird, Lettuce bird, Shiner, Peet bird, Salad bird, or American goldfinch. In winter it feeds on weed seeds and in summer adds several harmful insects such as plant lice, canker worms, small grasshoppers, and beetles to its diet of seeds of dandelions, thistles, ragweed, and other weeds.

Black-capped chickadee: Also called Common chickadee, Eastern chickadee, Black-capped titmouse, Black-capped tit. It eats both insects and seeds but a larger proportion of insects. These include several very harmful insects such as the eggs of the tent caterpillar, eggs and adults of plant lice, and weevils of several kinds.

Western meadowlark: Also called Common meadowlark, Field lark of the west, Lark of the west. It is found in the western United States east to the prairie districts of the Mississippi Valley, in Minnesota, Iowa, Missouri, Oklahoma, and Texas. Its food consists largely of harmful insects, such as grasshoppers and the caterpillars of other pests. It eats the seeds of many harmful weeds, too.

Tree sparrow: Also called Snow chippy, Winter chip-bird, Winter chippy, Tree bunting, Canada sparrow, Arctic chipper, Winter sparrow. It is found in eastern North America. In winter, it goes as far south as South Carolina, Tennessee, and Oklahoma. This bird destroys enormous numbers of weed seeds. Scientists have estimated that tree sparrows eat about 875 tons of weed seeds a year in an agricultural state about the size of Iowa. It gets its wintry names from the fact that it spends the winters in the temperate zone and may often be seen feeding on the weeds that stick up above the snow.

Cardinal: Also called Redbird, Cardinal grosbeak, Crested redbird, Virginia nightingale, Virginia cardinal, Kentucky cardinal, Cardinal bird. It is found in the eastern United States as far north as southern New York State; sometimes as far north as Maine or Massachusetts in the east, and Michigan and Wisconsin in the middle west; west through northern Illinois to southern Iowa and the edge of the Great Plains; south to Georgia, Alabama, and the upland regions of the Gulf States. It is a very valuable bird in insect and weed control. Among the harmful insects, it eats the Colorado potato beetle, the periodical cicada, cotton worm, scale insects, zebra caterpillar of the cabbage, cucumber beetle, corn-ear worm, cotton cutworm, codling moth, boll weevil, and others. It also eats seeds of a number of weed pests.

PAGE 241. Chewing insects do not have teeth. They have hard jaws with a toothed edge for chewing and grinding. The actual sizes of the insects shown in this picture are approximately as follows: Colorado potato beetle, 3/8 in.; striped cucumber beetle, 1/4 in.; green caterpillar, 1 in.; bean-leaf beetle, 5/16 in.; malaria mosquito, 1/3 to 1 in. depending on species; squash bug, 5/8 in.; potato-plant aphid, 1/3 in.; dog-day cicada, 2 in.; grape-leaf hopper, 1/8 in.

PAGE 242. Tent caterpillars are chewing insects. They are widely found on wild cherry, chokecherry, or apple trees. The adult lays the eggs in the fall. The caterpillars hatch in the spring. They soon spin the huge web, or tent, usually in the fork of a tree. All the caterpillars from one lot of eggs remain together in this tent until they are nearly full-grown. It acts as a shelter from which they emerge to feed when it is not too cool.

PAGE 245. Tomato horn worm. A widely distributed insect that does much damage in some areas.

TEXT. An excellent pamphlet that shows the important pests of vegetable garden plants and gives methods of control is "A Victory Gardener's Handbook on Insects and Diseases" published by the United States Department of Agriculture. (See Bibliography.) Your state department of agriculture will probably have bulletins also.

The teacher should stress the fact that DDT must be used carefully and according to directions. Indiscriminate use under improper conditions can prove dangerous to people and animals. Certain basic precautions should be observed, especially when using DDT in the home: Keep it away from food; avoid inhaling it; keep it away from open flames and avoid smoking when spraying with it—there is a fire hazard; be careful not to spill the oil solution on the skin, but wash at once if you do; never use the oil solution on animals; do not use it in any form on cats; remove canaries and goldfish from the room while spraying.

Procedure

This problem gives pupils an opportunity to extend and apply information learned in Unit 1, How Do Living Things Help and Harm

Each Other? Have pupils recall this information. If necessary, they should reread pages 22, 28, 29, 30, 31, 32.

Then have the children study the text and examine the pictures, which will help them learn to recognize common weed and insect pests as well as helpful birds. Be sure to stress the fact that many insect poisons are also poisonous to people, pets, and farm animals. Pupils may wish to watch an experienced gardener use insect poisons. They can discuss with him how to decide which poison to use and how to use it. For additional activities, see *Things to Do*, page 245, Nos. 3, 5, 6, 8, 10, and 11.

Questions (Page 244)

1. Weeds keep plants from getting enough sunlight, water, and minerals. Pulling them out, cultivating, using chemicals, protecting birds that eat weed seeds.

2. Where they live, what they eat, where they lay their eggs, how they change as they grow. Scientists must know these things so that they will know how, where, and when the insects can successfully be killed.

3. Suck sap; eat leaves.

4. *Cucumber beetle, cabbage worm, potato beetle:* stomach poison. *Aphid:* contact poison.

5. It kills both sucking and chewing insects but does not harm people, pets, or farm animals.

6. By eating weed seeds and insects.

Questions to answer (Page 244)

1. Answers individual but should show use of concepts taught in the unit.

2-3. Answers will vary. Write to the state agricultural college or the department of agriculture.

4. They would probably not be so successful, for gardeners and farmers could not know what was lacking in the soil, how to improve it, how to control weeds, insects, and plant diseases.

5. Yes, because the fish would decay and provide minerals for the plants.

6. *Sour clay:* add sand or ashes, humus, and lime or limestone. *Sandy:* mix clay and humus with it.

7. North so that the tall corn plants would not shade the other plants.

Things to do (Page 245)

1. Growing plants without soil is known as *hydroponics* or soilless culture. Information may be found under this heading in encyclopedias or books on growing plants.

2 and 4. Individual or group activities. Two trips might be made. Or if time and opportunity are limited, both of these activities might be combined in one trip by careful planning.

3. Many state departments of agriculture have bulletins describing the common weed and insect pests of the state.

5. Individual or group activity. A scrapbook or exhibit can be made of the articles.

6. Many magazines have articles on DDT. A librarian will help the children find them with the help of the *Readers' Guide to Periodical Literature.*

7. Write to the United States Weather Bureau or the Soil Conservation Service for such a map.

8. See Bibliography for books that will help in identification of birds and tell about their feeding habits.

9. Individual or group activity. Pictures of farm machines are plentiful in many of the common magazines. They may also be obtained from farm equipment manufacturers. The uses can be learned by consulting encyclopedias or a good dictionary.

10. Consult encyclopedias, high-school biology or botany texts. In the encyclopedias, the information may be under the heading of *plant diseases* or *fungi.*

11. See 6 above for sources of information. Articles on weed killers will cover this chemical. When sprayed on broad-leaved plants, it kills even their roots. It is especially good for lawns and for certain farm crops because it will not harm grasses, corn, sugar cane, etc.

Part Three BIBLIOGRAPHY

Supplementary reading for pupils

These books can be used as supplementary reading by the pupils. Many of them also furnish excellent illustrative material.

Arnold, Oren E. *Wild Americans.* Chicago: Whitman, 1937. (Western)

Baer, Marian E. *Pandora's Box: The Story of Conservation.* New York: Rinehart, 1939.

———. *Without Fire, A Book of Experiments.* New York: Rinehart, 1946.

Baker, R. Ray. *So That's Chemistry?* Chicago: Reilly & Lee, 1940.

Baruch, D. W. and Reiss, O. *My Body and How It Works.* New York: Harper, 1934.

Berry, Erick. *The Little Farm in the Big City.* New York: Viking, 1947.

Blair, Edna. *The Food Garden.* New York: Macmillan, 1943.

Blough, Glenn O. *Doing Work; Machines.* Evanston, Ill.: Row-Peterson, 1944.

Bock, G. E. *What Makes the Wheels Go 'Round.* New York: Macmillan, 1931.

Britton, Katherine. *What Makes It Tick?* Boston: Houghton Mifflin, 1943.

Brookes, Amelia. *Through the Ant Hill.* Philadelphia: Lippincott, 1941.

Bronson, W. S. *Children of the Sea; Horns and Antlers; The Grasshopper Book; The Wonder World of Ants; Turtles.* New York: Harcourt, 1937-1945.

Buff, Conrad and Mary. *Big Tree.* New York: Viking, 1946.

Chapman, Wendell and Lucie. *Beaver Pioneers.* New York: Scribner's, 1937.

Coevering, Jack Van. *Real Boys and Girls Go Birding.* Philadelphia: Lippincott, 1939.

Collins, A. Frederick. *Wonders of Chemistry.* New York: Crowell, 1942.

Emans, Elaine V. *About Spiders.* New York: Dutton, 1940.

Emerson, Alfred E. and Fish, Eleanor. *Termite City.* New York: Rand McNally, 1937.

Franklin, George Cory. *Wild Animals of the Five Rivers Country.* Boston: Houghton, 1947.

Freeman, Mrs. Mae Blacker and Ira M. *Fun With Chemistry.* New York: Random, 1944.

———. *Fun With Science.* New York: Random, 1944.

Goldsmith, M. O. *The Picture Primer of Indoor Gardening.* Boston: Houghton Mifflin, 1947.

Gould, Dorothea. *Very First Garden.* New York: Oxford, 1943.

Harrison, G. R. *How Things Work: Science for Young Americans.* New York: Morrow, 1941.

Huey, Edward G. *What Makes the Wheels Go Round.* New York: Reynal & Hitchcock, 1940.

Hylander, Clarence J. *Out of Doors in Autumn; Out of Doors in Spring; Out of Doors in Summer; Out of Doors in Winter.* New York: Macmillan, 1942-1943.

Johnson, Wm. and Fenn, I. M. *Popular Tools and Materials.* Chicago: Whitman, 1944.

Leyson, Burr W. *Elements of Mechanics.* New York: Dutton, 1944.

Maeterlinck, Maurice. *The Children's Life of the Bee.* New York: Dodd, 1919.

Melrose, Mary and Kambly, P. E. *Plants and Animals Live Together.* Chicago: Wilcox, 1942.

McClintock, Theodore. *The Underwater Zoo.* New York: Vanguard, 1938.

McIntyre, Flora. *Children of the Golden Queen.* Eau Claire, Wis.: E. M. Hale, 1945.

Moe, V. and Winter, M. *Animal Inn: Stories of a Trailside Museum.* Boston: Houghton, 1946.

Morgan, Alfred. *Simple Chemical Experiments.* New York: Appleton, 1941.

Novikoff, Alex. *From Head to Foot: Our Bodies and How They Work.* New York: International, 1947.

PARKER, BERTHA M. *Dependent Plants; Fire; Garden Indoors; Plant and Animal Partnerships; Saving Our Wildlife; The Garden and Its Friends; Thermometers, Heat and Cold.* Evanston, Ill.: Row-Peterson, 1941-1944.

PARKER, BERTHA M. and FRANK, O. D. *Plant Factories.* Evanston, Ill.: Row-Peterson, 1944.

PARKER, BERTHA M. and PARK, THOMAS. *Animal Travels.* Evanston, Ill.: Row-Peterson, 1941.

PATCH, EDITH M. *Desert Neighbors; Forest Neighbors; Mountain Neighbors; Prairie Neighbors.* New York: Macmillan, 1937-1947.

PEET, CREIGHTON. *How Things Work.* New York: Holt, 1941.

RIFKIN, LILLIAN. *When I Grow Up I'll Be a Farmer.* New York: Lothrop, 1944.

SCHMIDT, KARL P. *Homes and Habits of Wild Animals.* Chicago: Donohue, 1934.

SHIPPER, KATHERINE B. *The Great Heritage.* New York: Viking, 1947.

Sunset's Vegetable Garden Book. San Francisco: Lane, 1943. (Pacific Coast areas only)

Sunset Visual Garden Manual. San Francisco: Lane, 1946. (Eastern and Western editions)

WEBB, ADDISON. *Birds in Their Homes.* Garden City, New York: Garden City Publishing.

Writer's Program, Pennsylvania. *Life in an Ant Hill; Plastics; Rayon, Nylon, and Glass Fibers; Story of Bees.* Chicago: Whitman, 1940-1945.

YATES, RAYMOND F. *Fun With Your Microscope.* New York: D. Appleton-Century, 1943.

ZIM, HERBERT S. *Goldfish.* New York: Morrow, 1947.

For pupils and teachers

Guides

These are field books and guides that will help identify plants and animals. The reading may be difficult for the pupils, but the illustrations will be valuable.

ARMSTRONG, MARGARET and THORNBER, J. *Field Book of Western Wild Flowers.* New York: Putnam, 1915.

BISHOP, SHERMAN C. *Handbook of Salamanders.* Ithaca, New York: Comstock, 1943.

CAHALANE, VICTOR H. *Mammals of North America.* New York: Macmillan, 1947.

COLLINGWOOD, G. H. *Knowing Your Trees.* Washington, D. C.: American Forestry Assn., 1937.

FOLEY, DANIEL J. and MEIKLE, C. E. *Vegetable Gardening in Color.* New York: Macmillan, 1943.

GUBERLET, MURIEL L. *Animals of the Sea-Shore.* Portland, Oregon: Binfords & Mort, 1947.

HASKIN, LESLIE L. *Wild Flowers of the Pacific Coast.* Portland, Oregon: Binfords & Mort, 1947.

HOUSE, HOMER D. *Wild Flowers.* New York: Macmillan, 1936.

KRIEGER, LOUIS C. C. *Mushroom Handbook.* New York: Macmillan, 1947.

LUTZ, F. E. *Field Book of Insects.* New York: Macmillan, 1936.

MARSHALL, N. L. *Mushroom Book.* New York: Doubleday, Doran, 1923.

MATHEWS, F. SCHUYLER. *Book of Birds for Young People; Book of Wild Flowers for Young People; Field Book of American Trees and Shrubs; Field Book of American Wild Flowers.* New York: Putnam, 1921-1929.

MORGAN, ALFRED. *An Aquarium Book for Boys and Girls.* New York: Scribner's, 1936.

MORGAN, ANN HAVEN. *Field Book of Ponds and Streams.* New York: Putnam, 1930.

National Geographic Society. *Our Insect Friends and Foes and Spiders; The Book of Fishes; The Book of Wild Flowers.* Washington, D. C., 1933-1939.

PEARSON, T. GILBERT (Editor). *Birds of America.* Garden City, New York: Garden City Publishing, 1944.

PETERSON, ROGER TORY. *A Field Guide to Western Birds.* Boston: Houghton Mifflin, 1941.

———. *A Field Guide to the Birds* (2nd Ed.). Boston: Houghton Mifflin, 1947.

Pope, Clifford H. *Amphibians and Reptiles of the Chicago Area.* Chicago: Chicago Natural History Museum, 1944.

Reed, Chester A. *Land Birds East of the Rockies.* New York: Doubleday, Doran, 1940.

Schmidt, Karl P. and Davis, D. D. *Field Book of Snakes of the United States and Canada.* New York: Putnam, 1941.

Wolfe, Bernard. *Plastics.* Indianapolis: Bobbs-Merrill, 1945.

Magazines

American Forests. The American Forestry Association, 919 17th St., N.W., Washington 6, D. C.

Audubon Magazine. 1000 5th Ave., New York 28, New York.

Canadian Nature. Whittemore Publishing Co., Ltd., 177 Jarvis St., Toronto, Ontario, Canada.

Current Science and Aviation. 400 S. Front St., Columbus 15, Ohio.

Frontiers. The Academy of Natural Sciences, 19th St. and the Parkway, Philadelphia 3, Pa.

Popular Mechanics. 200 E. Ontario St., Chicago 11, Ill.

Popular Science Monthly. 353 Fourth Ave., New York 10, N. Y.

National Geographic Magazine. National Geographic Society, Sixteenth and M Streets, Washington 6, D. C.

Natural History Magazine and *Junior Natural History Magazine.* American Museum of Natural History, 79th at Central Park West, New York 24, New York.

Nature Magazine. 1214 Sixteenth St., N.W., Washington 6, D. C.

Science Illustrated. 330 West 42nd Street, New York 18, N. Y.

For the teacher

General References

These books will give the teacher additional background as well as information on specific questions that may arise.

Bailey, L. H. *Gardener's Handbook.* New York: Macmillan, 1942.

Beauchamp, W. L., Mayfield, J. C., and West, J. Y. *Everyday Problems in Science* and *Science Problems, One, Two,* and *Three.* Chicago: Scott, Foresman, 1946.

Bruere, M. B. *Your Forests.* Philadelphia: Lippincott, 1945.

Buchsbaum, Ralph. *Animals Without Backbones.* Chicago: University of Chicago Press, 1938.

Byrd, Oliver E. (comp. by). *Health Instruction Yearbook, 1944.* Stanford University, California: Stanford University Press, 1944.

Cahalane, Victor H. *Meeting the Mammals.* New York: Macmillan, 1943.

Carlson, A. J. and Johnson, V. E. *The Machinery of the Body.* Chicago: University of Chicago Press, 1941.

Comstock, Anna Botsford. *Handbook of Nature Study.* Ithaca, New York: Comstock, 1939.

Coulter, Merle C. *The Story of the Plant Kingdom.* Chicago: University of Chicago Press, 1936.

Gabrielson, Ira N. *Wildlife Conservation.* New York: Macmillan, 1941.

Graham, E. H. *The Land and Wildlife.* New York: Oxford, 1947.

Hegner, R. W. and Hegner, J. Z. *Parade of the Animal Kingdom.* New York: Macmillan, 1942.

Hylander, Clarence J. *The World of Plant Life.* New York: Macmillan, 1939.

Hylander, Clarence J. and Stanley, Oran. *Plants and Man.* Philadelphia: Blakiston, 1941.

Lampman, Herbert S. *Northwest Nature Trails.* Portland, Ore.: Binfords & Mort, 1933.

Lemmon, Robert S. *How to Attract the Birds.* Garden City, New York: Doubleday, 1947.

Lemon, Harvey B. *From Galileo to the Nuclear Age.* Chicago: University of Chicago, 1946.

Luhr, Overton. *Physics Tells Why*. Lancaster, Pa.: Cattell, 1943.

Macy, Icie Gertrude and Williams, H. H. *Hidden Hunger*. Lancaster, Pa.: Cattell, 1945.

Mangham, Sydney. *The Earth's Green Mantle*. New York: Macmillan, 1939.

McCollum, E. J. and Simmonds, Nina. *Newer Knowledge of Nutrition*. New York: Macmillan, 1945.

Morris, Percy A. *They Hop and Crawl*. Lancaster, Pa.: Cattell, 1944.

Parker, B. M. and Buchsbaum, R. M. *Balance in Nature*. Evanston, Ill.: Row-Peterson, 1941.

Pope, Clifford. *Snakes Alive and How They Live*. New York: Viking, 1937.

Rickett, Harold W. *The Green Earth*. Lancaster, Pa.: Cattell, 1943.

Romer, A. S. *Man and the Vertebrates*. Chicago: University of Chicago Press, 1933.

Sears, Paul B. *This Is Our World*. Norman, Okla.: University of Oklahoma Press, 1947.

Smith, V. C. and Trafton, G. H. *Using Science*. Philadelphia: Lippincott, 1942.

Williams, Samuel H. *The Living World*. New York: Macmillan, 1937.

Works Progress Administration. *American Wild Life*. New York: Wise, 1944.

Professional Literature

BOOKS

Arey, C. K. *Science Experiences for Elementary Schools*. New York: Bureau of Publications, Teachers College, Columbia University, 1942.

Childhood Education. Association for Childhood Education. 1201 16th Street, N.W., Washington 6, D. C.

Craig, Gerald. *Science for the Elementary School Teacher*. Boston: Ginn, 1940.

Croxton, W. C. *Science in the Elementary School*. New York: McGraw-Hill, 1937.

Garrison, C. G. *Science Experiences for Little Children*. New York: Scribner's, 1939.

Heiss, Elwood, Obourn, E. S. and Hoffmann, C. W. *Modern Methods and Materials for Teaching Science*. New York: Macmillan, 1940.

Hill, K. E. *Children's Contributions in Science Discussions*. New York: Teachers College, 1947.

Lynde, Carleton J. *Science Experiences with Home Equipment; Science Experiences with Inexpensive Equipment; Science Experiences with Ten-Cent Store Equipment*. Scranton, Pa.: International Textbook, 1937-1941.

National Society for the Study of Education. *Forty-Sixth Yearbook*, Part 1, "Science Education in American Schools." Chicago: University of Chicago Press, 1947.

Noll, Victor. *The Teaching of Science in Elementary and Secondary Schools*. New York: Longmans, 1939.

Pitluga, G. E. *Science Excursions into the Community*. New York: Teachers College, 1947.

Plaffman, Mary and Stern, Frances. *How to Teach Nutrition to Children*. Boston: Barrows, 1942.

Preston, Ralph C. *Science: An Approach in the Elementary School*. Philadelphia: University of Pennsylvania, 1945.

Rose, M. S. *Teaching Nutrition to Boys and Girls*. New York: Macmillan, 1938.

Underhill, Orra E. *The Origins and Development of Elementary School Science*. Chicago: Scott, Foresman, 1941.

Wells, Harrington. *The Teaching of Nature Study and the Biological Sciences*. Boston: Christopher, 1940.

Woodring, M. N., Oakes, M. E., and Brown, H. E. *Enriched Teaching of Science in the High School*. New York: Bureau of Publications. Teachers College, Columbia University, 1941. (Lists of available free and low-cost materials.)

MAGAZINES

Hygeia. American Medical Association. 535 N. Dearborn St., Chicago 10, Ill.

The Instructor. F. A. Owen Publishing Company. Instructor Park, Dansville, N. Y.

Progressive Education. American Education Fellowship. 289 4th Ave., New York 10, New York.

School Life. U. S. Office of Education. Federal Security Agency, Washington 25, D. C.

School Science and Mathematics. 450 Ahnaip St., Menasha, Wisc.

Science Digest. 200 E. Ontario St., Chicago 11, Ill.

Science Education. Science Education, Inc. 374 Broadway, Albany, N. Y.

Science News Letter. Science Service. 1719 N St., N.W., Washington 6, D. C.

PAMPHLETS, BULLETINS, AND MANUALS

Audubon Nature Bulletin (10 yearly). National Audubon Society. 1000 Fifth Avenue, New York 28, N. Y. (Formerly *School Nature League Bulletin*)

Cornell Rural School Leaflets. Cornell University, Ithaca, New York.

Craig, G. S. *Science in Childhood Education.* New York: Teachers College, 1944.

Departmental Bulletins of the United States Government.

Price lists of pertinent bulletins may be obtained without charge from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., from whom the bulletins are also ordered. The bulletins usually contain excellent illustrations.

A Curriculum Guide to Fire Safety for Elementary Schools. Washington: Office of Education, Federal Security Agency. U. S. Bulletin No. 8, 1946.

Blough, Glenn O. *Science.* Federal Security Agency, Office of Education, 1947. F S 5.7/a:Sci 27. 10 cents.

Common Birds of the Southeastern United States in Relation to Agriculture. U. S. Dept. of the Interior. Fish and Wildlife Service. Conservation Bulletin No. 15. 10 cents.

Forestry for 4-H Clubs. U. S. Dept. of Agriculture. Miscellaneous Bulletin No. 359. 10 cents.

4-H Club Insect Manual. U. S. Department of Agriculture. Miscellaneous Publication No. 318. 10 cents.

Nutrition Education in the Elementary School. Nutrition Education Series. Pamphlet No. 1. U. S. Office of Education, 1943.

Teaching Conservation of Wildlife through 4-H Clubs. By Ruth Lohmann. U. S. Dept. of Agriculture. Bureau of Biological Survey. Miscellaneous Publication No. 291. 10 cents. (Contains excellent conservation bibliography.)

National Science Teachers Association. *Time for Science Instruction.* Washington, D. C.: National Education Association, 1946 Yearbook.

Skinner, George A. *Wonder Stories of the Human Machine.* Chicago: American Medical Association. (A set of pamphlets which may be obtained at small cost from the association, 535 N. Dearborn St., Chicago 10, Ill.)

Stevens, B. and Steckmesser, G. *Teaching Science in the Elementary School.* New York: Progressive Education Association, 1942.

Todhunter, E. W. and Andes, H. L. *Nutrition Experiments for Classroom Teaching: A Handbook for Teachers.* Pullman, Washington: State College of Washington, 1942. (25 cents)

Turtox Service Leaflets; Turtox Teachers' Manuals; Turtox News. General Biological Supply House (see page 95 of the *Guidebook*). Treat topics concerning the collection and preservation of biological material; much interesting information about plants and animals. Free.

Zim, H. S. *This Is Science.* Washington, D. C.: Association for Childhood Education, 1945.

Part Four MATERIALS AND SOURCES

Care of Living Things in the Classroom

Animals

General suggestions. Quarters. Provide roomy and comfortable quarters for every animal—aquaria and terraria (see below) for land and water forms; cages of screen, hardware cloth, or other material for mammals, insects (see below), etc. The cage must be cleaned daily, or a diseased pet will result. *The cage should have a removable bottom for cleaning facilities and stationary containers for food and water.* Line cage with newspapers or other material that may be destroyed. Provide sleeping quarters such as straw or a comfortable box.

Water. Provide with fresh water daily.

Feeding. Feed daily. Most wild animals must be trained to eat in new living quarters. Patience is necessary. Try to imitate the living conditions of the animal as they were in its natural environment. Remove surplus food after animal has eaten. Provide plenty of food; the animal will not overfeed. There is no more pitiful spectacle than half-starved animals in a laboratory.

Delicate animals such as guinea pigs should be fed twice daily and at regular times. Early morning and late evenings are best. On Fridays provide enough to last over Sunday. Cold-blooded animals such as frogs, lizards, swifts, turtles, etc., do not require as much food as warm-blooded animals. One feeding a day is ample. A large feeding every other day is sufficient in most cases. In aquaria do not leave uneaten food to foul the water.

Vary diet to prevent weakness and disease. The following food list is suggested.

Snails: Lettuce leaves, aquatic plants, powdered meat, powdered cuttlefish bone.

Fishes: Prepared fish food, chopped beef, particles of earthworms.

Salamanders and lizards: Flies, earthworms, chopped beef, liver.

Frogs: Diet varies with kind of frog. Insects, fruit flies, roaches, earthworms, larvae, chopped beef, very small strips of liver, etc.

Turtles: Overripe fruit, lettuce, clover, carrots, strips of liver.

Snakes: Small frogs, mice, lizards, beef, liver, chicken scraps.

Rats and mice: Table scraps, cheese, wheat flour paste mixed with milk, pinch of salt and lime, dried yeast, lean meat, lettuce.

Guinea pigs and rabbits: Plenty of succulent green vegetables—at least body weight daily. Carrots, turnips, dry sweet hay, clover, different grasses, dry grain, apples and apple parings, apple cores, pear peelings, tomatoes (for rabbits, twigs with bark for gnawing occasionally), water cress, wheat and oat shoots.

The insect cage. Grow some plants from seed-corn, wheat, clover, grass, etc., in a large pot of earth, or transplant weeds or other plants suitable as food for the insects to be kept. Press a large lamp or lantern chimney into the soil, fitting the plants inside it. A small container of water should also be fitted inside the chimney. Place the insects inside the chimney and close the top with wire screening or mosquito netting. When the insects have eaten the food within the container, move it to a new pot of plants.

Ant colonies. It is not difficult to establish ant colonies for observation. The Lubbock ant nest is well adapted for use in the schoolroom since it shows all the tunnels and chambers. Such a nest may be obtained from one of the scientific supply houses listed on page 95 of the *Guidebook*. It is not necessary, however, to purchase an observation ant nest, as one similar to the Lubbock nest can easily be constructed.

Obtain two pieces of glass about twelve inches square. Lay one piece of glass flat on a table and glue one-quarter-inch strips of wood around three edges, using water glass or glass cement. On the fourth side leave two openings. (These openings may be made by using three short pieces of wood instead of a long one. Put one piece at each end of the fourth side and one in the middle. This will leave two openings.) After the glue is dry, fill the frame with a mixture of sifted loam and sand, leaving a space in the center for the ant colony and spaces near the two openings in the frame, which are to be plugged later to keep the ants from getting out.

Ant colonies may be found beneath logs or stones, or in underground nests in gardens and lawns. When a colony has been found, look carefully for a queen or two. The queen can be identified by her large size. (*The National Geographic Magazine* for August 1943 gives the life of ants and shows in pictures the different ant forms.) With a trowel, scrape up a queen and as many of the other ants, eggs, and larvae as possible and take them home in a glass jar with a tightly screwed lid. Place the ants in the center space left in the ant nest. Then glue on the top piece of glass. In one of the holes in the frame place a small sponge, which must be kept wet, as ants cannot be left without moisture. The other hole is for food. Bind all the edges with glass adhesive tape. Then plug the two holes with removable stoppers. Feed the ants from time to time, dropping bits of meat, bread, grains, sugar, drops of honey, and dried insects into the food hole. Keep the frame covered to exclude all light for a day or two. By then, the colony will be established and can be observed.

The aquarium. A square or oblong tank aquarium is the best type that can be had. Lacking that, the ingenious teacher will find many good substitutes, such as large-mouthed battery jars and fruit jars. Globes are not as desirable as other types, for they distort the appearance of animals and break easily. Thoroughly clean sand, natural objects that are found in streams (such as attractively colored pebbles that have been shaped by water action), and the proper kinds of plants and animals are the materials necessary for stocking an aquarium. A small net, rubber tubing for a siphon, and long-handled forceps are desirable.

SETTING UP THE AQUARIUM. Clean the container thoroughly. Put in a one- to two-inch layer of clean sand. Place the aquarium where it is to stay permanently. The most desirable place is one where it will not receive much direct sunlight, but plenty of diffused light, such as near a north window.

The close observer in the field will need no special instruction as to the types of plants desirable for the aquarium. Eel grass, water milfoil, pond weed, water cress, and certain kinds of algae can be collected from the habitat where they are growing and placed in the tank to grow under similar conditions. The florist or pet shop can furnish such cultivated varieties as vallisneria, sagittaria, elodea, ludwigia, etc.

In arranging the plants and natural objects, try to make them resemble a natural pond. Anchor each plant in the sand at the bottom of the aquarium by embedding about an inch of the base of the stem and placing pebbles around the base. The upper part of the plant can then be allowed to lie flat on the sand, as it will straighten to an upright position when the water is put in.

Place a large piece of paper over the plants and the sand, and siphon the water gently in on top of it. The paper will prevent displacing the sand as the water is poured in and should be removed when the aquarium has filled. Use water from a spring or clear stream, as tap water often contains chemicals that are harmful to animal life. Let the aquarium stand for several days until the plants adjust themselves. Then put in the animals.

A good caution is not to overstock the tank. The fish rule is "one inch of fish to one gallon of water." This does not include insects, tadpoles, etc., the number of these depending upon the size of the aquarium. An average amount of animals for one gallon of water is one one-inch fish, one tadpole, one snail, and several water insects. Goldfish should not be used in a school aquarium unless native types cannot be obtained. Use familiar animals that have been collected by the children, if possible. Some native fish that thrive in an aquarium are catfish, mud minnows, sticklebacks, and perch. Snails of the common fresh-water type are desirable as scavengers. Clams and fresh-water mussels should be used if possible. One is usually sufficient for an average tank. Very small turtles (one inch in diameter across the back) may be used. They must be well fed so that they will not disturb other animals. Rocks projecting out of the water must be provided for turtles, so that they can get above the water to breathe. Bullfrog tadpoles and newts or salamanders may be taken from springs and streams. Desirable insects are dragonfly nymphs, back swimmers, water boatmen, water striders, and whirligig beetles.

FEEDING. Feed sparingly, once a day on the average, and remove excess food as soon as the animals have eaten. Prepared fish food of several types is easy to use and suits many animals. A worm suspended on a string is a good change of diet. Small flies, water plants, and other natural foods, noted by observing animals' habits, should be provided. See the food list on page 90.

Caution: Watch the aquarium closely. The water may have to be changed often at first. *Animals use the oxygen of the water for breathing, while plants use the carbon dioxide which is a waste product of animal life. Plants make oxygen. In this way the balance of aquarium life is maintained.* Do not overfeed animals. Remove dead animals and plants immediately.

Plants

Pots and window boxes. TEMPERATURE. A daytime temperature of 65-70 degrees and a night temperature of 55-60 degrees is desirable in the schoolroom for normal plant growth. When the outside temperature is excessively low, protect the plants from freezing by placing newspapers between them and the windowpanes.

WATER. Water the plants only when they need it—when the soil is dry. Enough water should be given at one time to wet the soil to the bottom of the pots. Then wait until the soil is dry before watering again. Sprinkle the leaves thoroughly once a week in order to keep them free of dust and soot (with the exception of African violets, whose leaves should not be wet).

PESTS. Plants are frequently attacked on the underside of the leaves by small green lice, mealy bugs, and scales, which are lice with hardened outer coverings. To rid the plants of lice and mealy bugs, wipe the under parts of the leaves with soapy water made with a mild soap. Scales can be removed only by using a toothpick or dull, pointed knife to lift them. Then wash the affected parts with soap solution.

The terrarium. A moisture-tight container such as was used in the aquarium work is best suited to terrarium construction. It should be either square or rectangular because of the better view afforded. If the straight-sided type cannot be had, any glass jar or container may be used. The larger ones are more desirable. Use a piece of plain window glass for a cover.

Almost any plant that grows in the local environment may be raised successfully by simply noting its growing conditions and reproducing them as nearly as possible in the terrarium. Delicate plants that would die in a few days otherwise may be made to live for long periods in a properly regulated terrarium. The secret of success lies in controlling the moisture by means of a tight glass cover. Plants which require little or no moisture may be kept in containers with screen covers, or with glass covers and the presence of little moisture.

The terrarium should be placed where it will receive plenty of light and, if possible, a little early morning sunlight. Care must be taken that it does not receive enough direct sunlight to make the plants "scald" because of too high temperatures. A northeast window is ideal for the average terrarium. The desert type should be placed where it will receive plenty of sunlight for most of the day. Place the container in the location where it is to stay and leave it, as continual moving of the container is bad for both plants and animals.

Ordinary room temperatures are suitable for plants and animals usually found in the vicinity. If the temperature of the schoolroom falls very low over weekends, very little success can be expected. An average nightly temperature of 50 degrees and a daytime temperature of 75 degrees will give good results.

One of several kinds of habitats may be established in the terrarium, but only a few of the most common types will be discussed here. Establish first those that match the environment near the school and those with which the pupils are most familiar. Others may be established to show different conditions as interest grows.

WOODLAND TYPE. In the bottom of the container, place a layer of sand or coarse gravel about an inch and one-half thick. On top of this, place a layer of loose rich humus from the forest floor. On field trips with the children, select small plants that are found growing in the deep woods. Place in this miniature woodland such animals as may live there. A small salamander (land type) and two small toads will make a good collection. A small snake may be added if desired. Keep the soil moist, but do not allow the water to stand for long periods of time. Feed the animals with small insects such as house flies, worms, and small strips of liver. Keep the terrarium covered with glass. Exclude most direct rays of sunlight.

MARSH TYPE. Place a layer of gravel on a slope, so that it will be about four inches high at one end and about one inch at the other. Cover this layer with rich, moist earth from a bog. Put in plants that require much moisture —mosses (sphagnum is good), small clumps of marsh grass, and similar plants. Place water plants (see directions for aquarium), and put about two inches of water in the lower end. Animals such as small turtles, a small fish or two, a tadpole, small frogs, etc., will complete the animal life. Feed as directed on page 90 and keep covered.

DESERT TYPE. Construct this type of terrarium when a study of conditions prevailing in very dry countries is desirable. Use coarse gravel covered with sand as a base. Place small cactus plants of various types in natural positions. Cover the roots completely. Water very sparingly once every two or three weeks, as the plants tend to decay if watered too often. Keep a small pan of water in one corner for the animals to drink from. Animals such as horned toads and fence lizards may be kept successfully. Feed as directed on page 90. Cover the terrarium with screen wire.

List of Materials

The materials needed for the experiments and observations described in the pupil's book are listed below. Many of the items may be brought from home by the pupils. Some may be borrowed from upper-grade science rooms. Others may be bought locally in ten-cent stores, drug stores, hardware stores, pet shops, feed stores, florist shops, greenhouses, etc. It may be necessary to order a few items from supply houses. These items are printed in heavy black type.

QUANTITY	ITEM
–	Acids: 1 cup vinegar, 1 lemon
1 tbs.	Alcohol
1 piece	Aluminum
1	Auger
Spoonful	Baking powder
2 tsp.	Baking soda
1	Balloon, toy rubber
1	Basketball or volleyball
1	Bicycle pump
1 piece	Blotting paper
8	Boards: 2—any size; 1—thin, 2 feet long; 1—3 feet long, 3 inches wide; 1—smooth, 4 feet long, 6 inches wide; 1—8 feet long, 6 inches wide; 1—1 inch thick, 6 inches wide; 1 about 1 foot long
1	Bottle, small-mouthed
2	Boxes, small, same size
1	Box, wooden (larger than chalk box)
4 slices	Bread, each fresh
1	Bunsen burner (or other heat)
1 piece	Butter
2 or more	Cages for rats
4	Candles (2 inches high), 1 paraffin
2 pieces	Cardboard: 1—6 inches square, 1—1½ feet by 8 inches
1 stalk	Celery with several leaves
1	Chicken bone, slender
1	Clamp, metal screw-type
1 cup	Clay
4 pieces	Cloth (about 6-8 inches square)
1 quart	Container that can be heated
50 feet	Cord, strong
1	Cork (to fit test tube)
1	Crowbar or strong wooden stick
3	Dishes: 2 shallow, 1 to be heated
2	Dry cells
1	Egg beater
–	Elements: iron, copper, lead, etc.

QUANTITY	ITEM
1	Ferris wheel, toy
½ cup	Fertilizer
1	Flour sieve
4	Flower pots, 2 of them alike
–	Food for rats
–	Foods containing fats
–	Foods containing starch
4 pieces	Glass: 1—6 by 12 inches, 1—6 inch square
1 foot	Glass tubing to fit hole in cork
6	Glasses (tumblers)
1	Hammer with tack puller
–	Honeycomb
2	Hooks or nails
–	Ice or other means of cooling
1 bottle	Ink, red
Few drops	Iodine
Spoonful	Iron filings
Spoonful	Iron, powdered
Piece	Iron, rusty
5	Jars, glass: 2 with covers
1	Knife
3	Lamp chimneys
1 cup	Limewater
Strips	Litmus paper, blue
2	**Magnets**, bar
1	Magnifying glass
1 box	Matches
2 pieces	Metal, thin and flat
1 doz.	Metal balls or shot
2 quarts	Milk
1	**Motor**, toy
2 doz.	Nails: 2 small, several small iron, 1 doz. medium, 1 large
Few drops	Oil or grease
1	Orange
1	Orange squeezer
1	Pail or basket
4	Pans: 2 just alike, 1 iron, 1 flat

QUANTITY	ITEM
1 piece	Paraffin
1 doz.	Pencils, round
1	Penny or other coin
About 10	Plants: 2 the same size, 2 the same size and kind, 1 with aphids, several with different kinds of roots
2	Pulley blocks (with 2 wheels)
2	Pulleys
4	Rats, white (same age and size)
1 tsp.	Salt
Small box	Sand
1	Saw
1 tsp.	Sawdust, coarse
1	Scales
1	Scissors
1	Screw eye
2 doz.	Seeds, 1 doz. bean or radish
1 sq. ft.	Sod, dry
3-4 quarts	Soil, 1 cup loam
2	Spools, strong
1	Spring balance
1 tsp.	Starch
1	**Stopper with hole in center**
1	Strainer
6 feet	String, medium heavy
2 tbs.	Sugar
2 tbs.	Sulphur, powdered
2	Supports (about 1 foot high)
1 box	Tacks
1	**Test-tube holder**
3	**Test tubes**
2	Thermometers
1	Wagon, toy
Several	Weights: stones, sand, books, etc.
6 feet	Wire, copper (3 feet covered)
30 pieces	Wood: 2 rough; 2 smooth; 3 narrow, for water wheel and for support; 3 small, to make pulley; 3 for wheel and axle; 1, 3-sided block 2 inches high; 12 splinters

Supply Houses

Biological Supply Company, 1176 Mt. Hope Avenue, Rochester 7, N. Y.
Cambosco Scientific Company, 37 Antwerp Street, Boston 35, Mass.
Carolina Biological Supply Company, Elon College, North Carolina.
Central Scientific Company, 1700 Irving Park Road, Chicago 13, Ill.; 441 Clinton Avenue, Newark 8, N. J.; 79 Amherst Street, Cambridge 42, Boston, Mass.
Chicago Apparatus Company, 1735 N. Ashland Avenue, Chicago 22, Ill.
Clay-Adams Company, 44 East 23rd Street, New York 10, N. Y. (models, charts)
Denoyer-Geppert Company, 5235 Ravenswood Avenue, Chicago 40, Ill. (models, charts)
Eimer and Amend, 633 Greenwich Avenue, New York 14, N. Y.
General Biological Supply House, 761-763 East 69th Place, Chicago 37, Ill.
Heil Corporation, 210 South 4th Street, St. Louis 2, Mo.
Marine Biological Laboratory, Woods Hole, Mass.
Millard-Heath Company, 325 Olive Street, St. Louis 2, Mo.
New York Scientific Supply Company, 28 West 30th Street, New York 1, N. Y.
A. J. Nystrom & Company, 3333 N. Elston Avenue, Chicago 18, Ill. (charts)
Oregon Biological Supply Company, 303 N.E. Multnomah, Portland 12, Ore.
Scientific Supplies Company, 122 Jackson Street, Seattle 4, Wash.
Standard Science Supply Company, 1232 N. Paulina Street, Chicago 22, Ill.
Standard Scientific Supply Corporation, 34-38 West 4th Street, New York 12, N. Y.
Tricker, William, Inc., Tanglewood Drive, Independence, Ohio; Saddle River, N. J.
Ward's Natural Science Establishment, Inc., 3000 Ridge Road, East, Rochester 9, N. Y.
Welch (W. M.) Scientific Company, 1515 N. Sedgwick Street, Chicago 10, Ill.

Visual Aids

American Museum of Natural History, Central Park West at 79th Street, New York 24, N.Y. Loans teachers silent and sound films, lantern slides, and cased collections.

Association Films (Y.M.C.A. Motion Picture Bureau): 347 Madison Avenue, New York 17, N.Y.; 19 South LaSalle Street, Chicago 3, Ill.; 3012 Maple Avenue, Dallas 4, Texas; 351 Turk Street, San Francisco 2, Calif.

Bray Studios, Inc., 729 Seventh Avenue, New York 19, N.Y. Films on many subjects.

Bristol-Meyers Co., Educational Dept., 630-C 5th Avenue, New York 20, N.Y. Wall chart showing teeth and their care.

L. W. Brownell, 176 East 32nd Street, Paterson, N.J. Slides on birds, mammals, reptiles, insects, botany.

Encyclopaedia Britannica Films, Inc., 20 North Wacker Drive, Chicago 6, Ill. Films on all subjects. (Has libraries formerly belonging to Eastman and Erpi.)

Films, Incorporated, Education Department: 330 West 42nd Street, New York 18, N.Y.; 611 Tillamook Street, Portland 12, Ore.; 64 East Lake Street, Chicago 1, Ill.; 101 Marietta Street, Atlanta 3, Ga.; 109 North Akard Street, Dallas 1, Texas.

General Electric Company, Educational Service Division, Publicity Department, 1 River Road, Schenectady 5, N.Y. Write for catalog. Motion pictures distributed through local offices.

Keystone View Company, Meadville, Pa. Lantern slides for courses in biology.

Metropolitan Life Insurance Company, 1 Madison Avenue, New York 10, N.Y. Films on medicine, nutrition, safety.

National Audubon Society, 1000 Fifth Avenue, New York 28, N.Y. Lantern slides of North American birds and mammals.

New York University Film Library, 26 Washington Place, New York 3, N.Y.

Santa Fe Film Bureau, 1401 Railway Exchange Bldg., 80 East Jackson Blvd., Chicago 4, Ill. Films on canyons in the west and on locomotives. Free.

Society for Visual Education, Inc., 100 East Ohio Street, Chicago 11, Ill. Films, slides and slidefilms, kodachromes, and charts on all subjects.

U. S. Department of Agriculture
Films: Motion Picture Service, U.S.D.A., Washington 25, D. C.
Information on slides: Extension Service, U.S.D.A., Washington 25, D. C.

U. S. Public Health Service and, in many cases, your state Board of Health will have a film library or list of recommended aids.

United World Films, Inc., 445 Park Avenue, New York 22, N.Y. (Now owns the large film library of Bell and Howell.)

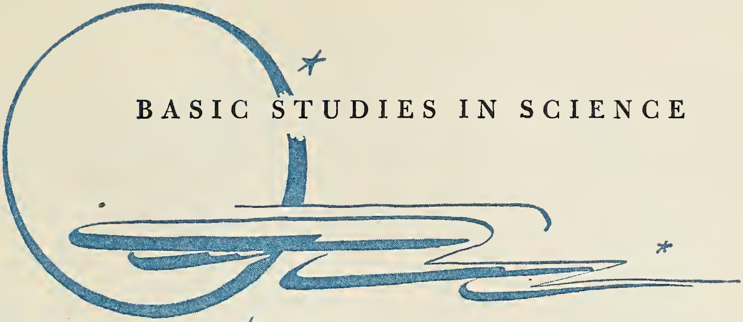
Visual Aids Service of New Jersey State Teachers College Library, Upper Montclair, N.J. Maintains an up-to-date card catalog and will furnish information relating to suitable audio-visual and teaching aids.

Westinghouse Electric Corp., 306 Fourth Avenue, Pittsburgh 30, Pa. Sends free films and charts on physical sciences and health.

Many public school systems and state universities have departments of visual education which maintain film libraries. State museums often loan slides to teachers.

5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 55 54 53 52 51 50

BASIC STUDIES IN SCIENCE



Discovering Our World

SCIENCE FOR THE MIDDLE GRADES

by WILBUR L. BEAUCHAMP
MARY MELROSE WILLIAMS
GLENN O. BLOUGH

2

SCOTT, FORESMAN AND COMPANY
Chicago, Atlanta, Dallas, New York

ACKNOWLEDGMENTS

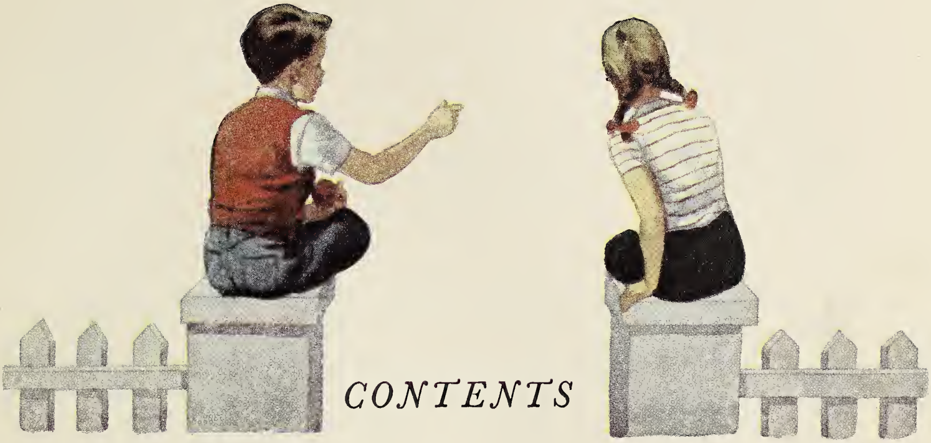
FOR MANY SUGGESTIONS that were very helpful in making this edition of DISCOVERING OUR WORLD, BOOK TWO, the authors are much indebted to the supervisors and teachers who read the material critically. Among those who gave help, special thanks are due Miss Anna E. Burgess, Supervisor of Elementary Science, Cleveland, Ohio; Dr. Joe Young West, Maryland State Teachers College, Towson, Maryland; Miss Winifred Barry, Supervisor of Schools, Hollis, New York; Miss Dorothy Hunt, Principal, The Brookwood School, North Kansas City, Missouri; Miss Irene Thomas, Principal, The Perry School, Ann Arbor, Michigan.

The drawings were made by Raymond E. Craig, Fiore Mastri, Leon L. Pray, and Helen Snyder.

Acknowledgment is made to the following for permission to publish the photographs on indicated pages: Acme Newspictures, Inc., 30 (center), 36, 53, 56, 162 (left), 214, 242; J. C. Allen from Ewing Galloway, 91 (left); Aluminum Company of America, 119; American Airlines, 47 (top); The American Forestry Assn., 43; Gustav Anderson from Ewing Galloway, 132; L. D. Bailey and *American Forests,* 20; Dr. A. Allan Bates and the Westinghouse Electric Corp., 138; Carl Berger, 9 (left); *Better Homes and Gardens,* 97, 233; Black Star, 49, 52, 78 (right); Brown Brothers, 15; L. W. Brownell, 22, 24 (left), 31 (bottom), 40, 218; Caterpillar Tractor Co., 169; Century-Allen, 13, 146 (right), 190; Century Photos, Inc., 18, 21, 152, 168 (left), 170, 182, 183, 186, 187; Chicago Academy of Sciences, 30 (top); Chicago and North Western Railway, 63; Chicago Natural History Museum, 10, 12, 37; Cleveland Board of Education, 220, 229 (left); Cushing from Sawders, 87, 101 (right); De Laval Steam Turbine Co., 61; G. A. Douglas from Gendreau, 98 (left), 100 (left), 106 (left); Ewing Galloway, 33 (left), 46, 54 (top), 83 (right), 90, 121, 140, 143, 144, 161, 162 (right), 176, 178, 237; Philip D. Gendreau, 50, 51, 106 (right), 226 (left); Hercules Powder Co., 142; Ferdinand S. Hirsh, 14, 96, 102; The Hoover Co., 57; Paul G. Howes, 16, 17, 32 (left); International Harvester, 33 (right), 57 (left), 204; Robert H. Johnson, 172; Kaufman & Fabry Co., 64 (top), 92; Keystone View Co., 101 (left); Keystone-Underwood, 55 (left); Leon Koenigsberg, 27 (center-right); Erling Larsen from Frederic Lewis, 98 (right); *Life,* 193; *Look* from The National Safety Council, 166; *Market Growers' Journal,* 227; Meisel from Monkmeyer, 141; Merck & Co. from the American Institute of Baking, 191; A. F. Mueller, 94; Museum of Science and Industry, 146 (left); J. Horace McFarland Co., 24 (right), 25 (right); National Dairy Council, 195, 196; National Safety Council, 165, 168 (right), 171; Dr. E. Lawrence Palmer, 174; *Parents' Magazine* by F. P. G., 74; *Pix* from Publix Pictorial, 47 (bottom); *Popular Science Monthly,* 95 (left); William J. Robbins and The New York Botanical Garden, 212; H. Armstrong Roberts, 76 (right); Rock Island Railway, 59; Albert I. Rose from Frederic Lewis, 87 (right); William A. Scharon, 44; Kurt Schelling (from *Fortune* by special permission), 68; Ben Schnall from Frederic Lewis, 91 (right); Science Service, Inc., 222; *Screen Traveler* from Frederic Lewis, 78 (left); A. F. Sozio from Gendreau, 100 (right); Hugh Spencer, 25 (left), 27 (left, left-center, right), 28, 30 (bottom), 208, 210 (right), 217; Tennessee Dept. of Conservation courtesy The American Forestry Assn., 38, 41 (right); Trowbridge from R. I. Nesmith, 70; Underwood and Underwood, 9 (right); U. S. Beet Sugar Assn., 206; U. S. Dept. of Agriculture, 26, 31 (top, center), 41 (left); U.S.D.A., Bureau of Entomology, 32 (center, right); U.S.D.A., Bureau of Home Economics, 192; U.S.D.A., Bureau of Plant Industry, Soil, and Agricultural Engineering, 28 (center), 29, 207, 225, 226 (right), 230, 232 (left), 234; U.S.D.A., Forest Service, 148; U.S.D.A., Soil Conservation Service, 34, 35, 181, 238; U. S. Dept. of the Interior, Fish and Wildlife Service, 19, 42; U. S. Gypsum Co., 163; H. A. Vandenbree, from *The Instructor,* Dec., 1942, by permission of Miss Isobel Willcox and the F. A. Owen Publishing Co., 6; Wisconsin Conservation Dept., 39.

Copyright, 1947, by Scott, Foresman and Company

PRINTED IN THE UNITED STATES OF AMERICA



CONTENTS

To the boys and girls who study this book. . . 6

UNIT ONE: *How do living things help and harm each other?* 11
How do animals help each other? 13
How do plants help animals? 19
How do animals help plants? 21
How do plants help each other? 24
How do plants harm other living things? 26
How do animals harm other living things? 30
How do plants help us? 33
How do animals help us? 36
How do we conserve the living things that help us? 38

UNIT TWO: *What makes things move?* 45
Why do things move? 45
Where do your muscles get their energy? 48
How do springs get their energy? 50
What is the greatest force in the world? 51
How do we use moving water? 53
How do we use moving air? 56
Why can steam move things? 59
How do we use the force of explosions? 62
How does electric current move things? 64
How can one form of energy be changed to another? 67

UNIT THREE: *How is our work made easier?* 71
What is a machine? 72
How do we use levers? 73
How do we use inclined planes? 78
How do we use pulleys? 82
How do we use a wheel and axle? 88
How can one wheel turn another wheel? 91
How can we make machines work better? 93
How can we use machines safely? 97

UNIT FOUR: *How do heating and cooling change materials?* . 103
How do heating and cooling change the size of solids? 103
What happens to liquids when they are heated or cooled? 107
How is hot water used to heat a house? 110
How do heating and cooling change gases? 111
How does a hot-air furnace heat a house? 116
How are solids changed to liquids? 118
How are liquids changed to gases? 120
How is water vapor changed to liquid water? 122

UNIT FIVE: *What are things made of?* 125
How are materials different from each other? 126
How can we change the characteristics of materials? 130
What are elements? 133
How are elements joined together? 135
How do we use chemical changes? 140
How can we prevent harmful chemical changes? 143

UNIT SIX: *How do we control fire?* 149
What do we need to make a fire? 151
What do fires need to keep them burning? 154
What happens when things burn? 156
How can we conserve our fuels? 160
What can we do to prevent fires? 164
How can we put out fires? 168

UNIT SEVEN: *Why do you need food?* 177
What does food do for you? 178
What foods keep you warm and give you energy? 181
What foods help you grow and keep healthy? 185

How do vitamins help you keep well? 188
What does water do for your body? 193
What habits will help you get the proper foods? 194
What does cooking do for your food? 199

UNIT EIGHT: *Where does all the food of the world come from?* 205
How do roots help plants get food materials? 206
How do water and air get into the leaves? 209
How does a green leaf make food? 211
What becomes of the food made by a green leaf? 214
How do plants that are not green get food? 216

UNIT NINE: *How can you make a garden?* 221
How can you plan a garden? 222
How do we get the soil ready for planting? 225
How do we plant a garden? 229
How do we take care of growing plants? 233
How are plants protected from their enemies? 239

Science words 246

Index 250

To the Boys and Girls Who Study This Book

For hundreds of years, explorers have been discovering new places in the world. Columbus discovered a new land, and other explorers discovered new regions in many parts of the earth. But nearly all of the lands in our world have now been discovered and explored.

Traveling to faraway places is not the only way of discovering our world. We also discover our world when we learn what kind of world it is. All around you, there are thousands of things that you have never seen or heard about. They are just as interesting and just as exciting as anything that the great explorers ever found.

In this picture the boys and girls are discovering interesting things about the world they live in. You are very much like these boys and girls. You have eyes and ears, and you can think and plan. You can see and hear many of the things that go on around you, and you can find out how they happen.

Here are some of the things that happen near you every day. Can you explain how they happen?

Water flows downhill.

Animals help plants.

Plants help animals.

Fire makes things burn.

Bees help flowers make seeds.

Green plants make food from materials in the soil and air.

Steam locomotives pull trains.

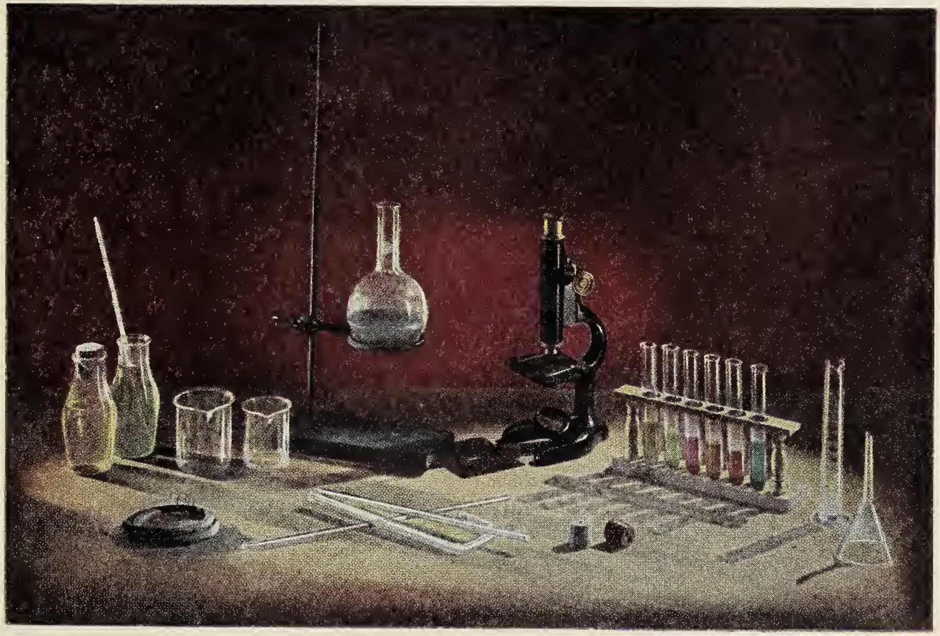
People plant tiny seeds that grow into flowers or vegetables.

Probably you do not know how these things happen. But do you know how to find out?

One way to find out how such things happen is to *look carefully* at the things around you. To do this, you need to think about what you are seeing. You need to take plenty of time so that you will discover as much as you can.

Another way of finding out about the things around you is to *read* books. There are certain things to remember when you read books to get information. Some books are written to be read for fun. They do not always give you correct information. Be sure that the books you read for information were written by authors who write books to give information. You may have to read several books before you decide whether the information is correct.

The books you read in science should not be too old. The science information in old books may have been



thought correct when the books were written. But new discoveries are made every year. And so new books are likely to be more nearly correct.

One of the most interesting ways of discovering new things is to do experiments. When you experiment, you try out different things to see how they work. You will want to do many experiments so that you can learn about the things around you.

When scientists do experiments, they use many of the things you see in the picture on page 7. Perhaps you will have some of these things to use at school. But if you do not, you can do many experiments just as well with bottles, glasses, and other things that you bring from home.

There are certain things you should be careful about when you experiment. Read this list of things to do and try to think of them while you are doing your experiments.

1. Be sure to follow the directions that are given in your book.
2. Watch carefully to see what happens.
3. Think carefully to understand why it happens.

4. Try your experiment more than once so that you can be sure that you do it correctly.

5. Always work carefully.

Many of the discoveries in our world have been made by scientists. Scientists are men and women who study the things on the earth and inside the earth. They are really discovering our world because they are always finding out new things about it.

Scientists discover new things by experimenting and by looking carefully at things about them. They make many discoveries in their science laboratories. But they also make discoveries wherever they happen to be.

Not all of your science discoveries will be made in your schoolroom. Many of them will be made at home and everywhere around you outdoors.

If you want to find out what discoveries this science book will show you, look at the Contents on page 3. It will tell you some of the things that you are going to learn.

If there are some other questions that you would like to ask, make a list of them. Then see how many of them you can answer as you study DISCOVERING OUR WORLD.

As you use this book, you will find some new words that scientists use. You will want to know what they mean so that you can use them, too. In the back of this book is a list of Science Words. The list tells you how to pronounce them. It also tells you what the words mean. Turn to page 246 and look at the list of Science Words so that you can see how it will help you.

★ *In Unit One You Will Learn* ★

★ *How animals help each other* ★ *How plants help animals* ★

★ *How animals help plants* ★ *How plants help each other* ★

★ *How plants harm other living things* ★ *How animals harm other living things* ★

★ *How plants help us* ★ *How animals help us* ★

★ *How we conserve the living things that help us* ★

* UNIT 1 *

How Do Living Things Help and Harm Each Other?

Do you know that fish helped make buttons for your clothes? Many buttons are made from clam shells. Not many years ago, the men who make these little white buttons became worried, because the clams were disappearing. So the men asked scientists to find out why. This is what the scientists discovered.

When young clams are first hatched from eggs, they are not much bigger than a pinhead. They float around in the water until they fasten themselves to the gills of fish. There they stay until they are big enough to live without the help of the fish. The young clams that do not fasten themselves to the gills of fish soon die.

Can you guess why the clams were disappearing? It was because fishermen had caught most of the fish that the clams needed. So, of course, the clams could not stay alive. Without the fish there could be no clams, and without the clams there could be no shells for buttons.

This story tells you just one of the many strange ways in which living things need and use each other. Here is another story that shows you how living things help and harm each other.

Would you believe that mountain lions and wolves could save a forest? High up in the mountains in the western part of our country, there is a beautiful forest. A few years ago, many of the trees and other plants in this forest were dying, because deer were killing them. This may seem strange, because deer have lived in forests for hundreds of years without destroying the forests.

Yet this is what was happening. In this forest, wolves and mountain lions had been killing many of the deer and eating them. The men in charge of the forest decided to kill the mountain lions and wolves so that the deer would be safe.

After the men did this, almost every deer that was born grew to full size.

If many deer ate the twigs and bark of these trees, what would happen to the trees?

The herds of deer became larger and larger. Soon the herds were so large that there was not enough food for them. They became so hungry that they gnawed the bark off the trees. Of course, this killed many trees. Then the men had to kill some of the deer to save the trees. Do you see now how the wolves and the mountain lions had helped save the forest?

This story you have just read about the forest, the deer, the mountain lions, and the wolves shows another one of the strange ways in which plants and animals need each other and use each other. Living things need other living things almost as much as they need air and water.

You, too, are a living thing. Every day of your life, your plant and animal neighbors help you in some ways and harm you in other ways. This unit will tell you many ways in which living things need and use each other. You can discover many other ways yourself if you watch your living neighbors closely when you are outdoors.

Before you read these pages about plants and animals, you must be sure that you do not get a wrong idea. Do not get the idea that plants and animals know that they are helping or harming each other. Plants and animals need food, shelter, air, water, and light. As they try to get these things, they sometimes help and sometimes harm other living things. This helping and harming just happen to take place. The living things do not plan to help or harm each other.

Suppose you take a walk across the fields and through the woods or to some park in your town. Watch every animal you see and try to find out what the animal is doing. Study the plants you find. As you watch these living things, try to find answers to these questions. How do living things help each other? How do living things harm each other?

How do animals help each other?

One day, a science class went to parks and vacant lots in their town to watch plants and animals. The boys and girls also kept watching after school and on weekends when they were outdoors. They watched to see what they could find out about how living things help each other. Then they talked about what they had seen. First, they talked about animals.

"I know one way animals help each other," Henry said. "My father keeps honeybees, and I know that bees live together in hives."

The teacher then told the class that honeybees are called *social* animals because they live and work together. They have to live together in a *colony* to stay alive. Sometimes there are as many as 60,000 bees living in a colony.

This colony of bees has left its old home and is moving into a new one.

WORKER

QUEEN

DRONE

Almost all of the bees in the hive are called *worker* bees. They do all the work of the hive. Other bees are called *drones.* There are not many drones in a hive. They do no work, but the bee family could not get along without the drones. A drone is the father of the colony. All of the bees are either workers or drones except one bee. This bee is the largest in the colony. She is the mother and is called the *queen* bee. The pictures at the top of this page show you a worker bee, a queen bee, and a drone.

A beehive is almost like a city, with every bee doing a certain kind of work. Some bees fly over the fields and meadows, gathering materials for food. They find these materials in the flowers of plants. One of the materials is a sweet juice called *nectar.* The bees use the nectar to make honey. This honey is food for the bees. Bees also gather *pollen* from the flowers. Perhaps you have seen pollen in flowers. It looks like yellow dust. Bees use the pollen to make a kind of food called *beebread.*

Some of the worker bees are wax makers. These bees eat all the food they can and then attach themselves to each other and hang in long strings from the top of the hive. Each bee clings to the bee above it. In a short time, wax begins to ooze from the undersides of their bodies. Other worker bees take this wax and use it to make honeycombs. In these wax combs, the bees store their honey. They also put beebread in these combs. The queen bee lays her eggs in these combs, too.

Some of the bees are housekeepers. They pick up the pieces of wax that fall to the bottom of the hive and carry them outside. When bees die in the hive, these housekeeper bees carry the dead ones out.

Of course, there is always danger that some enemy may enter the hive. It is the duty of the guard bees to make sure that no strangers enter. If a wasp or some other strange insect or a bee from another colony tries to come into the hive, the guard bees fight it and sting it to death.

These hundreds of worker bees must be supplied with fresh air while they are working in the hive. So some of the bees fan their wings swiftly back and forth to move the air and to bring in fresh air.

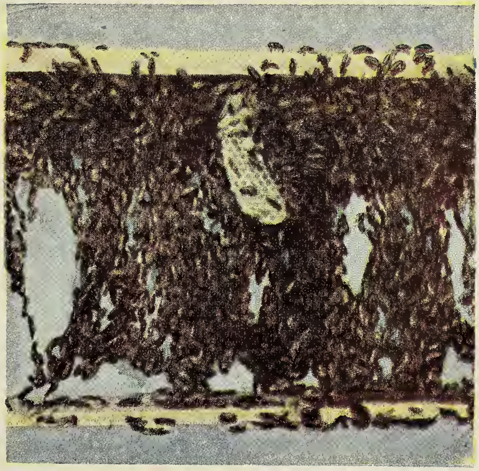
But all of this work would be useless without the queen. The queen bee lays all the eggs. Without her, there would be no new bees to take the places of those that die. The hive would soon be empty, because workers live only about six weeks.

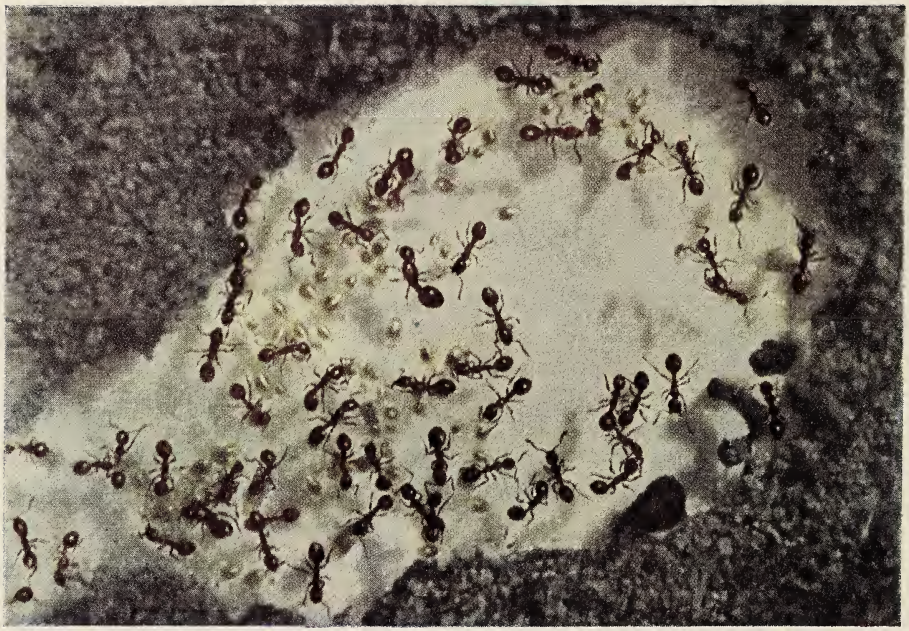
Does the way the bees divide up their work remind you of a community? In a city or a town there are street cleaners, policemen, carpenters, storekeepers, and many other kinds of workers. They help each other by doing different kinds of work. No one person does everything.

But there is one very important difference between a bee community and a community of people. Men and women *plan* the work in a community. They know why they help each other, and they know that they are helping each other. Bees cannot think. So, of course, they cannot plan. They live together and help each other without knowing why they do so. They do not even know that they are helping each other.

Ants also are social insects. It will be easy for you to have a colony of live ants in your classroom. You can dig up an ants' nest and put it in a glass jar with a fine screen over the top. Then if you tie paper around the jar so that the light will be shut out, perhaps the ants will make tunnels in the soil near the glass.

In the picture at the left, some of the bees are making the honeycomb. On the right, the bees are filling the comb with honey.





Here is part of an ants' nursery. The small, light-colored objects are young ants.

Most of the brown or black ants live in nests built in sand or loose soil. Here they dig long tunnels and make many rooms. Some of these rooms are nurseries where the young ants are taken care of until they can take care of themselves.

There are also storerooms for food. And would you believe it, some rooms are used for sleeping! Yes, ants sleep. When an ant returns to the nest, carrying a supply of food, other ants rush out to meet it. They brush the dust off the ant. Then the ant goes to one of these sleeping rooms where it soon is fast asleep.

There are three kinds of ants in an ant colony, just as there are three kinds of bees in a bee colony. But in an ant colony there are usually several queens. In a very large colony of ants, there may be fifty queens. The queen ants lay the eggs, too. In every nest, there are hundreds of worker ants. Some go to get food. Some look after the queens and feed them. Other workers take care of the eggs. Others guard the colony.

Scientists who have studied ants have found a very strange way in which animals help each other. They have found out that ants keep "cows."

The ant cows are really little plant lice, called *aphids*. The picture on this page shows two ants with their cows. These aphids suck the juice, or sap, from plants. The aphids use some of this juice for food. But ants "milk" the ant cows to get some of the juice for themselves. They do this by stroking the ant cow with their feelers. When the ant cows are stroked, they give off a drop of the juice. Then the ants drink the "milk."

But this is only part of the story. The ants take good care of their herd of ant cows! They keep other insects from eating the aphids, and they take care of the aphids' eggs. Through the cold winter, the ants keep the eggs and the cows down in the ground where they will not freeze. When the warm spring days come and the leaves are growing on the plants, the ants bring the newly hatched plant lice out into the sun and put them on the leaves. There the plant lice have plenty of food. The ants have really taken their cows out to pasture!

You can find many other examples of how animals live together. If you watch a mother and father robin feed the young birds, you will discover that the parent robins make hundreds of trips every day to bring food to the hungry young robins. Even after the young birds have begun to fly, the mother and father bring them worms and insects. The bird family lives together only as long as the young birds need to be taken care of. Then the family life is over.

Many other animals live together while the young need the mother's care. When young rabbits are born, they are as helpless as little kittens. For many days after young rabbits are born, they snuggle close to their mother and drink milk from her. The mother keeps them warm and safe.

Some kinds of animals join together so that they can capture food more easily. A group of wolves is called a *pack*. When a pack of wolves finds a deer or an elk in the woods, the wolves attack the animal and eat it. One wolf would have a hard time killing the larger animal, but many

Prairie dogs live together in villages. One or two sit up on top of their mounds to keep watch for enemies.

wolves together can kill it easily. Birds often join together to fight an enemy. Did you ever see a flock of little birds chasing a big crow that had been trying to rob their nests of eggs?

Some kinds of animals warn each other of danger. Beavers do this by striking their flat tails on the water. This makes a loud noise. It is the signal for other beavers to dive under water and swim to their homes. Crows give warning cries, and the flock flies to shelter and safety. Many other kinds of animals help each other by giving warning signals.

Animals need and use other animals in many, many ways. It would take you a long, long time to find out all there is to know about these ways. If you have been watching your animal neighbors and reading about them, you have probably discovered many things that are not told in this book.

---

1. *Why are some animals called* social *animals? Give some examples of social animals.*
2. *List some ways in which animals help each other by living or hunting in groups. Give an example of each way. If you can, name other animals than the ones given in this book.*
3. *What is one big difference between an animal community and a human community?*

How do plants help animals?

When the boys and girls of the science class had learned how animals help each other in many ways, they decided to find out how plants help animals. One Saturday, Bill and John took a hike through the woods and across the fields. They had not gone far before they saw a squirrel scampering along the ground. Soon they saw that he was helping himself to nuts that lay on the ground under some hickory trees. Quietly the boys watched. They saw the squirrel carry the nuts away to a hole high up in a tree.

"The squirrel eats the nuts and uses the tree for a home, too," said Bill. "And, of course, a tree is a plant."

As Bill and John walked along, they saw other animals using plants for food. Cows, horses, and sheep were eating grass in the fields near the woods. Birds were eating fruits in the trees, and other birds were picking up the seeds of plants.

"Some animals certainly could not get along without plants," said John. "They use plants for their food."

All animals need plants. Horses, cows, sheep, deer, and elephants never eat meat. Cats, dogs, tigers, lions, foxes, and many other animals eat meat. But even these animals could not live if there were no plants, because the animals they eat use plants for food. All animals must live in a place where there are plants.

A duck has made a nest in the tall reeds. Her eggs will be well protected there.

As the boys were walking along the edge of a grassy field, they were startled by a sudden noise in the grass. There, almost under Bill's feet, a tiny mouse jumped up and bounded away across the field. The boys searched in the grass, and in a minute they were bending over a nest of tiny mice. The tall, thick grass and the weeds made a very good place for the mother mouse to raise her family. Here she was protected from her enemies and from the hot sun. The inside of the nest was lined with soft grass and leaves.

While the boys were looking at the nest of mice, they heard a tapping sound on a tree near by. A woodpecker was using its strong, pointed beak to make a deep hole in the tree. In this hole, the woodpecker would lay her eggs. When the eggs were hatched, the hole would make a good home for the young woodpeckers. The flicker in the picture is using a hole in a tree for her home.

Many other birds find good nesting places among the branches of the trees. An oriole hangs its basketlike nest from one of the highest branches. It uses grass and twigs to make the nest. Most birds could not make their nests without using grass, twigs, leaves, or the bark of plants.

There were many other animals in the woods, but the boys did not discover them. These animals were small, and the boys never thought to look for them in their hiding places. If they had looked under the leaves of plants, they would have found many kinds of insects. Many kinds of small animals live under the leaves of plants that grow close to the ground. Crickets, grasshoppers, ants, small moths, cutworms, spiders, and snails live in the shelter of these leaves.

1. *What are some of the ways in which plants help animals?*
2. *Name five different animals that you have seen using plants. Tell how the plants helped the animals.*
3. *Explain why grass is very important in your life.*

In the picture on the left, bees are crawling over a flower looking for nectar and pollen. The bee at the right has many grains of pollen sticking to its body.

How do animals help plants?

It was rather easy for the boys and girls to see how plants help animals. But, at first, they could not see how animals helped plants very much. Animals always seemed to be destroying plants by eating them. But the boys and girls started out to see what they could discover. They read, asked questions, and looked carefully at plants and animals.

One of the most interesting things the boys and girls learned was how bees help flowers. You have probably seen bees crawling around over them. You know that the bees are gathering nectar and pollen. Pollen is very important to flowers. Plants cannot have seeds unless pollen gets down into the part of the flower where the seeds are made. Seeds will grow into better and stronger plants if pollen from one plant gets into the flowers of another plant.

Bees carry pollen. When a bee climbs into a flower, some of the dust-like pollen sticks to its hairy legs. When the bee crawls around on another flower, some of this pollen is brushed off. So every flower that the bee visits gets pollen from some other flower. Many kinds of flowers cannot make seeds at all unless bees or other insects carry the pollen. In this way, bees and flowers are like partners. Bees get nectar and pollen that they need for food. The flowers get the pollen that they need to make the seeds that will grow into new plants. Many butterflies, moths, and other kinds of insects also help spread pollen from flower to flower.

Animals help plants in another interesting way. Insects are the most dangerous enemies of plants. Scientists say that if all the insects that are born were allowed to live, in ten years they would eat up all the plants in the world. But birds are the greatest protectors of plants. Many kinds of birds eat insects for food. In this way, millions of insects are destroyed every day. So these birds are helping the plants stay alive.

You will hardly believe the number of insects that birds eat. Scientists have figured that the birds in Massachusetts eat about 21,000 bushels of insects a day during the summer months of the year! Each bushel has about 120,000 insects in it. Scientists say that in New York State birds eat 3 million bushels of harmful insects every year.

Earthworms are animals that also help plants. Sometimes they are called "living plows," for they dig their way through the ground by eating soil. The soil goes in one end of the earthworm and out the other. In this way, earthworms help keep the soil loose, so that air and water can get down to the roots of plants. Perhaps you have seen little piles of soil near holes that earthworms have made in the ground. These little piles

Can you see the little piles of soil near this earthworm's hole?

are made of the soil that has gone through an earthworm.

A scientist once figured that an acre of good garden soil had 50,000 earthworms in it. He also figured that 36,000 pounds, or 18 tons, of soil passed through the bodies of these earthworms every year. Perhaps you thought that earthworms were good only for fish bait, but now you can see that they help the roots of plants get the air and water the plants need to stay alive.

The day that Bill and John hiked through the fields and woods, they found that they had helped plants in a very funny way. They had not planned to help, and they did not notice how they were helping until they sat down under a tree to rest.

"Look at your pants, Bill. They're covered with burrs!" said John.

Bill laughed, "Look at them on your sweater, too."

The boys found many kinds of plant seeds sticking to them. As they picked the seeds off, they dropped them to the ground. Do you know what probably happened to the seeds?

Animals that have fur or hair are the best carriers of these seeds that stick tight. They carry them far and wide until the seeds fall off or are rubbed off. In this way, the seeds from one plant may grow into new plants miles away. Did you ever pick burrs out of the hair in a dog's tail? Inside these burrs, there were many seeds. After you dropped them on the ground, they probably grew into plants far from the place where the dog picked them up. Their free ride on the dog's tail helped the plants spread.

Seeds sometimes get faster rides than dogs, sheep, horses, and other four-legged animals can give them. They are carried far and fast by birds flying from place to place.

---

1. *Bees and flowers are partners. Tell how each one helps the other.*
2. *What are the most dangerous enemies of plants? What animals help protect the plants against these enemies?*
3. *How do earthworms help plants?*
4. *Give one reason why you find the same kinds of plants growing in so many different places.*
5. *Tell some of the ways in which animals help plants. Give an example of each way. If you can, name other animals than the ones given in this book.*

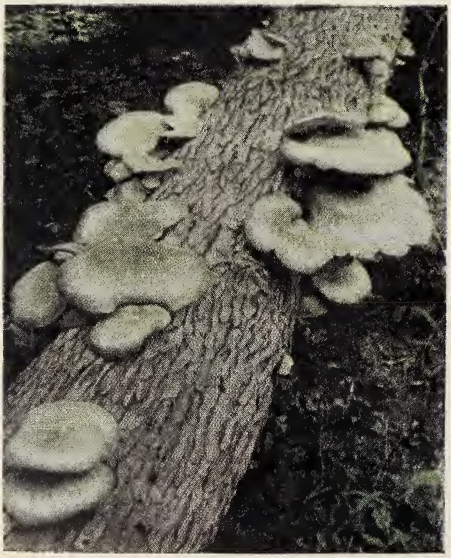
How do plants help each other?

WHILE THE CLASS was watching plants and animals to see how they help each other, the children were bringing to school many interesting things that they found outdoors. One day, Nancy brought to class a strange-looking thing that she had found growing from the side of a log. The picture at the left on this page shows you what Nancy found.

"It surely isn't an animal," said Nancy. "And it doesn't look like a plant."

But it was a plant even though it was not green. It was a kind of plant called a *fungus*. We call them *fungi* when we are talking about more than one fungus. There are many different kinds of fungi. You will find them growing on other plants. Sometimes they grow on live plants, sometimes on dead plants. They even grow on animals. Sometimes they grow out of soil that has decayed plants in it. Fungi cannot make their own food as green plants do. So they get food by using the food that the green plants have already made.

The fungus growing on the tree shows you that plants sometimes help other plants by supplying them with food. Mushrooms and puffballs are also fungi. They cannot make their own food, either. They grow in the ground, but they get their food from plants that have died and decayed.

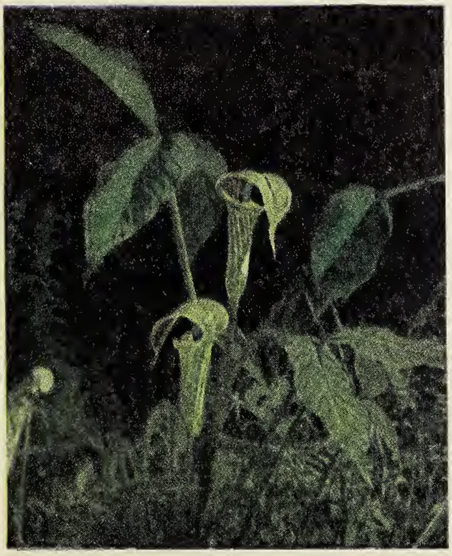


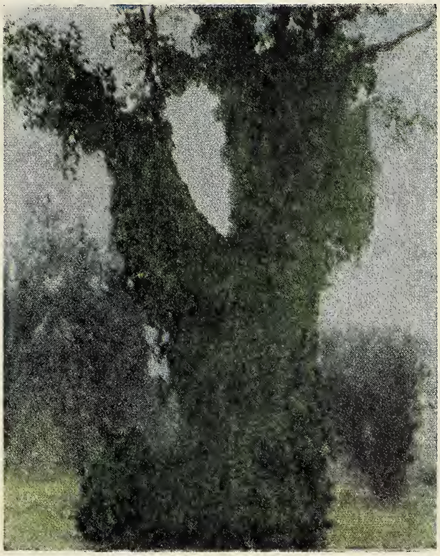
The mistletoe that we use for decoration at Christmas time must have the help of other plants, or it cannot grow. It is not a fungus, for it can make its own food. But mistletoe does not get water from the soil. And, of course, it must have water to stay alive. Mistletoe gets water by fastening itself to the branches or trunk of a tree. As the water from the roots travels up through the tree, the mistletoe takes the water it needs to stay alive.

Have you ever seen a jack-in-the-pulpit, like the one in the picture on this page? You will have to hunt in the damp, shady woods to find one. This plant will not grow in the bright sunlight. It must be protected by other plants. Ferns, too, need the protecting shade of larger plants around them. Many kinds of plants that cannot grow in the hot sun are helped by the shade of other plants.

In a woods near a field that was once a forest, there are many kinds of plants that do not grow in the field. These plants used to grow where the field is, too. But after the trees were cut down, these plants could not stay alive, because the shade was gone. The plants in the field are ones that grow in the sun and do not need shade.

But some plants need the help of other plants to get sunlight. Look at the picture on this page. The vine has climbed up until it almost covers the tree. It is using the tree to lift itself up into the sunlight and the air.



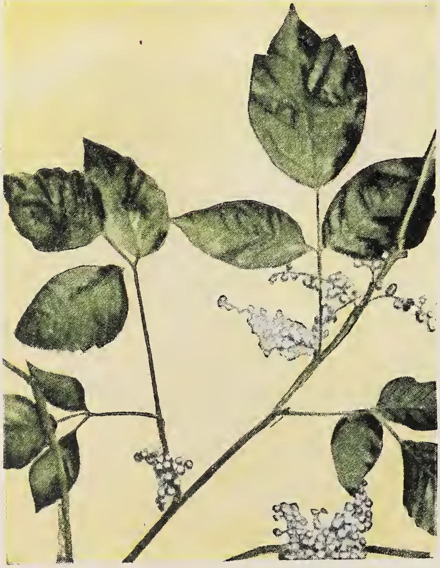


There is one way in which every plant helps some other plant. When the plant dies, it falls to the ground. Then it slowly decays and becomes part of the soil. When leaves fall from the trees, they mix with the soil and decay. The food materials in the plants and leaves go back into the soil, where they can be used again by new plants. Have you seen the black, spongy soil in a forest? Other plants grow well in this rich soil.

---

1. *What is a* fungus? *Name some* fungi.
2. *How is a fungus different from a plant such as grass?*
3. *Why must mistletoe grow on other plants?*
4. *How do some plants help other plants get sunlight?*
5. *Why are plants in forests often different from plants that grow in open fields?*
6. *How do all plants help other plants get food?*
7. *List as many ways as you can in which plants help other plants.*

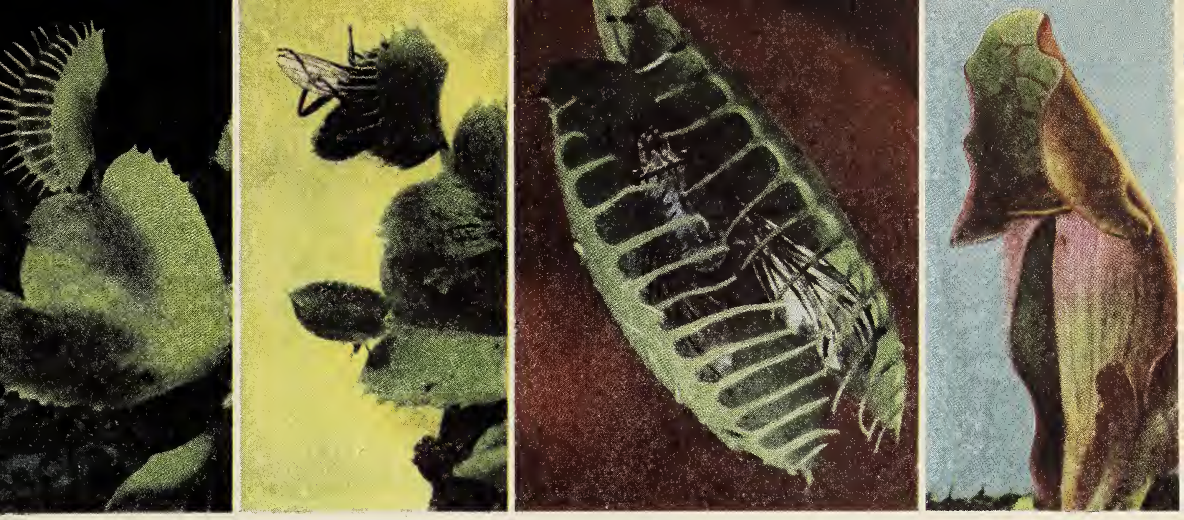
How do plants harm other living things?



Notice that the leaves are in three's!

One morning Bill came to school with his arms and hands almost covered with bandages. Everyone wanted to know what the trouble was. Sally thought he had been burned, but Bill explained that it was poison ivy. He had been out on a hike Saturday and sat down to rest. He did not notice the poison ivy on the ground.

Some of the boys and girls did not even know what poison ivy looked like. So the teacher showed them a picture like the one on this page. Look closely at the picture so that you will remember what poison ivy looks like. Sometimes the leaves have smooth edges, and one kind has leaves that look like oak leaves. But



You may be surprised to learn that some kinds of plants eat insects! The Venus's-flytrap is a plant like this. Its leaves have short bristles on them. When an insect lights on the leaf and touches these bristles, the two halves of the leaf come together. The insect is trapped. The pitcher plant has leaves that look like a pitcher. They have bristles inside of them. An insect that crawls down inside the leaf cannot get out again.

they are always in three's. The stems and white berries are just as poisonous as the leaves.

If you touch poison ivy, the first thing to do is to wash yourself with laundry soap and hot water. But it is best to learn to know the plant so that you will not touch it.

You have been discovering how plants and animals help each other. Bill's experience shows you that plants may also harm other living things. Perhaps you have been pricked and scratched by thorns. These thorns scratch and tear any animal that brushes against them.

If you live on a farm, you may know that cows sometimes get sick from eating a plant called white snakeroot. This plant poisons the milk of a cow. There are several kinds of plants that make horses, sheep, and cows sick and may even kill them. Many kinds of plants will also make people sick and sometimes kill them. If you are hiking out in the country, never eat berries or any other parts of plants unless you know that the plants are harmless.

The mistletoe that you read about on page 25 shows another way in which plants harm living things. Mistletoe robs trees of water. If mistletoe grows too thickly on a tree, the tree will die. The fungi that grow on living trees harm the trees by taking food from them.

There are many kinds of fungi. Some are tiny. Some are big. Whenever they grow on living things, they

are harmful because they are using the living things for food.

Some kinds of mushrooms are good to eat. You can buy them in almost any grocery store. But other kinds of mushrooms are deadly poisonous. Only people who know the difference between the kinds that are poisonous and the kinds that are not poisonous should ever pick mushrooms to eat. Many people have died from eating the poisonous kinds.

Look at the pictures on this page. Do you see how the corn, the apple, and the plums have been spoiled? Tiny fungi have spoiled them. If you live on a farm, you probably know about such things as wheat rust, apple rust, potato blight, and corn smut. These are all diseases of plants that are caused by tiny fungi.

If you want to see what one kind of fungus looks like, keep some bread moist for a few days. You will see mold growing on it. Mold is a fungus. Perhaps you have seen mold on old damp leather or on fruit that has spoiled.

There are other very tiny plants called *bacteria*. Some kinds of bacteria often harm other living things. They cause many of the diseases that we may have. They also cause some of the diseases that farm animals may have. Some bacteria even attack other plants and give them diseases.

You learned that every green plant needs to get water and food materials from the soil to keep growing. You also learned that plants must have sunshine so that they can grow. If plants are too close together, some of them take water and sunlight from others. The stronger plants live. But the weaker ones grow poorly, or they die. Weeds in your garden are enemies of your flowers and vegetables because the weeds take sunlight, food materials, and water from them. If there are too many trees in a yard, there may not be enough water for all of them. And the lawn may be shaded so much that grass does not grow well.

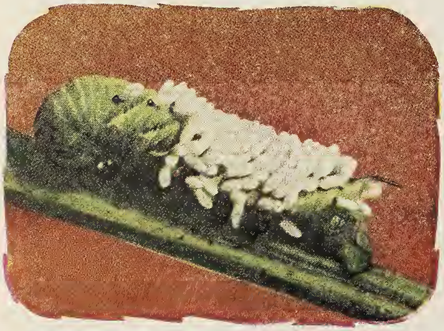
When plants grow farther apart, they are not shaded by each other's leaves. So there is plenty of sunlight for all of them. Their roots can find plenty of water, too. Where too many plants are growing close together, every plant is an enemy of every other plant. It is almost as if they were fighting each other for the things they need to keep them alive.

---

1. *How may every plant be an enemy of some other plant?*
2. *Why is it a good idea to get rid of weeds in a garden?*
3. *Why should plants not be grown too close together in a garden?*
4. *Give three ways in which plants harm other plants.*
5. *Why is it sometimes necessary to pull out some of the plants when they are growing in a row in a garden?*
6. *Tell three things you have learned about fungi.*
7. *Make a list of the ways in which plants harm animals. Give an example of each way.*

The corn that was planted near this tree cannot get the water and food materials it needs to grow. The roots of the tree are taking these materials from the soil.

How do animals harm other living things?



If you watch animals, you can easily see that they spend most of their time hunting for living things to eat. They are hunting other animals or eating plants. Most animals catch other animals, as the weasel in the picture has done. But some of the insects have another way of using other animals for food.

The caterpillar in the picture is being eaten by insects hatched from eggs laid on its body. A kind of fly laid the eggs on the caterpillar and left them there. When the eggs hatched, the young insects needed food. So they began to eat the caterpillar.

Many animals eat plants. Rabbits often eat the leaves of garden plants just after they have grown an inch or two. Rabbits and some other animals sometimes kill young trees by gnawing off the bark.

But as you know, rabbits and other of the larger animals are not the most dangerous enemies of plants. The most dangerous enemies of plants are the insects. Try to think how insects harm trees and other plants.

Probably you have seen leaves with big holes in them where they have been eaten by insects. You may have read how grasshoppers by the millions sometimes light on a field of wheat, oats, or corn and eat almost every plant growing in the field.

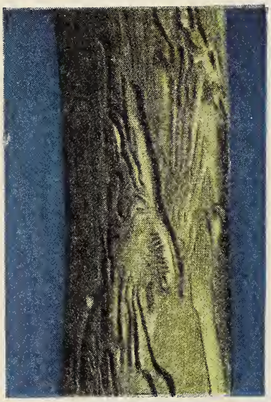
If you remember that insects go through changes as they grow, you can understand how they can damage plants in many ways. Many insects look like little worms when they first hatch from the eggs. These little wormlike creatures are called *larvae.* Each one is called a *larva.* A larva finally changes into a full-grown insect.

Many insects lay their eggs on the stems, roots, leaves, and flowers of plants. When the eggs hatch, the larvae eat the plants. You may have seen larvae eating the leaves of trees or of vegetables in your garden.

Did you ever bite into a "wormy" apple? The worm that you found was the larva of an insect. The larva was hatched from an egg laid by a kind of moth. This moth lays its eggs on apples. In about a week, tiny larvae hatch from the eggs and eat their way into the apples.

There are kinds of flies that ruin fruits and vegetables in much the same way that the moth larva spoils apples. They dig holes in the fruits or vegetables and lay their eggs in the holes. The larvae hatch from the eggs and eat the fruits or vegetables.

Other kinds of larvae that hatch from insect eggs eat the leaves, stems, and other parts of plants. Some of these are cabbage worms, cutworms, and cornworms. They are all insect larvae. Almost every kind of plant has some kind of larva that eats it.



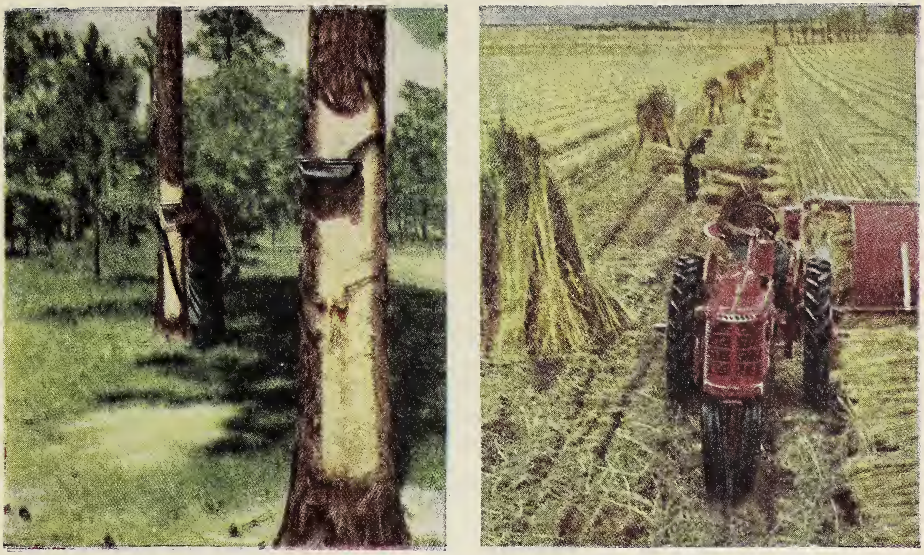
Many kinds of full-grown insects kill plants by sucking the sap from the plant. You know that plants need this sap for food. When too many of these insects get on a plant, the leaves turn yellow. Then the plant dies. Other kinds of full-grown insects eat the leaves and even the wood of plants.

Look at the pictures on this page. Do you see that insects have bored holes all through the wood? These holes were made by a kind of beetle. Millions of valuable pine trees have been killed by this kind of beetle. If you live where cotton grows, you have heard of the cotton boll weevil. This is a kind of beetle that kills cotton plants. The full-grown beetle eats the leaves and lays its eggs on the part of the plant where the cotton grows. The larvae that hatch from these eggs spoil this part of the plant so that the cotton cannot be used.

If insects were let alone, they would soon destroy all plants in the world. Can you imagine a world without plants? You know what would happen to all of us. We would have nothing to eat. There would be no fruits and vegetables. And there would be no cows, chickens, sheep, and pigs. These animals that we use for food could not live long without plants. They need grass, corn, wheat, oats, and other plants for their food.

---

1. *What is the main reason why animals harm other living things?*
2. *Name five animals that you have seen harming other animals.*
3. *Name five animals that you have seen harming plants.*
4. *Why does knowing how insects grow help people fight them?*
5. *Tell three ways in which insects harm plants.*



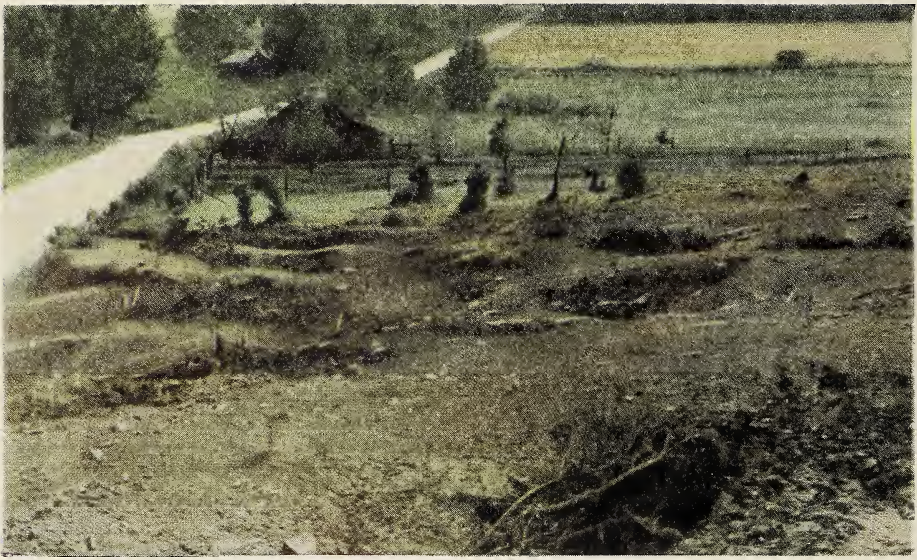
The men in the picture on the right are harvesting hemp, grown for its fibers.

How do plants help us?

A SCIENCE CLASS once made a list of all the different plants we use for food. They named over twenty-five plants. How many can your class name? Think of all the vegetables, fruits, cereals, and nuts you eat. Every year, the people of our country eat millions of bushels of wheat, potatoes, and corn. Besides these things, we eat millions of bushels of apples, oranges, carrots, and other fruits and vegetables every year.

Even the tiny bacteria help us with our food supply. Some of them cause plant and animal bodies to decay. In this way, materials that plants need are added to the soil. Other bacteria are used in making vinegar and some kinds of cheese.

But food is not all that we get from plants. Suppose you look around your schoolroom. Study everything in the room. What things come from plants? Is there any rubber in your schoolroom? The rubber was probably made from rubber trees. Surely there is paint in your room. From one kind of pine tree, we get an oil used to make paint. The picture on the left on this page shows how this oil is collected. Did any of your clothes come from plants? Of course, there is wood in your room. The paper in this book was made from wood.



The rain has washed away the soil and is making little valleys on this bare hillside.

Many kinds of plants are used to make medicine. Castor oil comes from the beans of the castor-oil plant. The wonderful drug *penicillin* is made from a kind of mold.

There is another very valuable thing that plants do for us. You would probably never think of it. Plants help keep rivers from overflowing their banks. Dead leaves and stems and branches fall to the ground and make a soft, spongy covering for the soil. When spring comes and the snow melts and there are heavy rains, the water soaks down into this spongy covering. But where the soil is bare, most of the water runs off quickly into the brooks and rivers. Of course, the brooks and rivers cannot hold all this water. So they overflow their banks and flood the country. You have probably read about the great damage that is caused by floods.

Did you ever see a river in the early spring when the snow was melting, or just after a long, heavy rain? What color was the water? It was yellow or brown and muddy. Where did the mud come from? Perhaps you thought it came from the bottom of the river. But it really came from the land along the river. Rains are always washing soil into the rivers.

In some parts of our country, millions of acres of good farm land have been spoiled because people cut down the trees that grew on the hillsides or plowed up the grass that grew on

Many pine trees were planted on the hillside and their roots are now holding the soil.

the prairies and plains. Then rushing water from rains and from melting snow carried the soil away from these places. When plants grew in these places, their roots helped hold the soil and kept it from washing away.

Plants keep the wind from blowing the soil away, too. Their roots form a network in the soil, and their leaves and stems slow the wind down. Not many years ago, huge dust storms swept across our country. Strong winds blowing over bare ground picked up the dry, loose soil and carried it for hundreds of miles in great clouds of dust. Many farms were ruined, and the farmers had to move away.

Since that time, plants have been used to help prevent this loss of soil. Grass and other plants are used to cover bare soil and hold it. Trees are planted to check the wind. You can see how plants help us by holding the soil in place and helping to prevent dust storms as well as floods.

---

1. *What kinds of plants did you eat yesterday and today? Name them.*
2. *What plants furnish you with clothes, rugs, curtains, and bedding?*
3. *How do plants help prevent floods and dust storms?*
4. *How do plants protect the soil?*

These men live on a sheep ranch. How are animals helping them?

How do animals help us?

IF YOU LOOK at things in your schoolroom, at home, and outdoors, you will find many answers to the question "How do animals help us?" Your geography book, too, will give you answers to this question.

How many different kinds of animals help furnish us with food? Our meals would be very different if we did not have cows, chickens, sheep, pigs, and fish. Animals help furnish us with clothes, too. Cows and sheep help supply our clothes. Even alligators and snakes furnish us with leather. We often use their skins for shoes, traveling bags, belts, and purses.

Animals work for us and protect us, too. Horses, oxen, camels, and even dogs carry and pull loads for us. Dogs often protect us from enemies. Cats kill mice and rats. Some of the wild animals help us, too. Skunks and snakes eat large numbers of harmful insects, mice, and rats. Many of the harmless snakes are among our best helpers and should be protected. Snakes should not be killed unless they are poisonous.

You already know how birds protect us from the insects that would soon destroy all our plants. Most hawks and owls also protect our plants. They kill rats, mice, ground squirrels, gophers, chipmunks, rabbits, and many other small animals. These animals eat the roots, bark, and other parts of our fruit trees. Or they eat the grains and vegetables from our farms and gardens.

You would probably never think of some of the other ways in which animals help us. Glue is made from the hoofs, skins, and horns of animals. Animal hair is used in plaster to help hold the plaster together. Camel's hair, the hair of squirrels, and pig bristles are used to make paintbrushes. Leather belts made from the skins of animals help run machines.

Of course, this book can tell you only a few of the ways in which animals help us. There are many more things to learn. You can discover some of them by reading, asking questions, and watching things around you. A good idea is to have a separate group answer each one of these questions and then report to the class.

1. How do animals help supply us with food?

2. How do animals help supply us with clothing?

3. How do animals help us do our work?

4. How do animals protect us against enemies?

5. How do animals help us in other ways?

The groups can help show what they have discovered by bringing pictures and samples of materials that show the different ways in which animals help us.

---

1. *Name all the animals you can think of that*
   - *a) Supply us with food.*
   - *b) Supply us with clothing.*
   - *c) Help us do our work.*
   - *d) Protect us against enemies.*
   - *e) Help us in other ways.*
2. *Tell just what each of these animals does for us.*

Raising trees to hold the soil and supply lumber is one way to help with conservation.

How do we conserve the living things that help us?

DO YOU LIVE on a farm? Or did you ever take care of a garden? Boys and girls who live on farms or who have gardens know many ways in which we help plants and animals. We provide food and shelter for our horses, cows, sheep, pigs, and chickens. We even have doctors for sick animals. We are just as careful with our plants. With plows, hoes, and other tools, we loosen the soil so that air and water can get down to the roots of the plants. We put fertilizer in the soil so that the plants will have materials to make food. We spray fruit trees and other plants with poison to kill harmful insects. And we fight the weeds that rob our plants of water, food materials, and sunlight.

Did you ever hear anyone talk about *conservation?* It means protecting something or using it wisely. Everywhere in our country, men and women, and even boys and girls, are interested in the conservation of our wild plants and animals. You have already learned why we should protect some of our wild animals such as skunks, harmless snakes, and birds. Let us find out some other reasons why it is important to conserve the wild plants and animals.

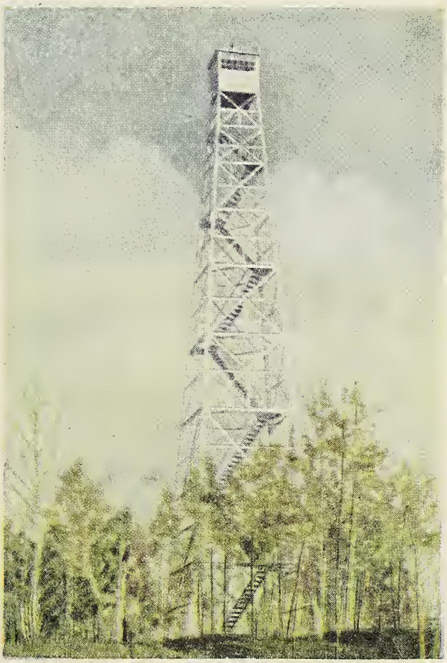
For hundreds of years, the people of our country have used plants and animals. They have cut down the trees to make houses, furniture, ships, and many other things. Millions of trees were cut down and burned so that the land could be used for farms.

Trees are among the most important of the living things that we are now trying to save. Our government is spending millions of dollars each year to plant new trees and to protect the trees that are already growing. Thousands of acres of land are planted with new trees each year. In many places, there are great forests where no trees can be cut. In other forests, the workmen are very careful not to harm the young trees when they cut down the large ones.

Forest fires have robbed us of millions of beautiful and useful trees. These same fires have killed thousands of wild animals. Our government has found ways to help protect our forests from fire. On this page is a picture of a tower in one of our country's big forests. During dry weather, a man stays in this tower and watches the forest for any signs of smoke. He can see for miles and miles over the treetops. There is a telephone in the tower. If the man sees smoke from a forest fire, he telephones to men who will find the fire and put it out.

Lightning starts many forest fires, but most fires are started by careless men and women and boys and girls. A lighted match or cigarette or cigar dropped in the grass or leaves may start a fire that will destroy thousands of trees and animals. Campers forget to put their campfires out, or they put them only partly out when they leave. The wind begins to blow, and sparks fly out into the leaves and grass. A terrible forest fire starts. Are you careful with fire when you are in the woods? Later on, you will learn how to be safe with campfires.

Every year insects destroy more trees than forest fires do. Scientists are at work in many places studying the insects that harm the forest trees. They find out where these insects live, what they eat, and other things about them. Then they work out ways of



Gentians, trilliums, and lady's-slippers are protected in many states. Are they in yours?

killing the insects before they do too much damage to the trees. Many thousands of trees have been saved by the work of these scientists.

You can help protect our wild plants. What do you do when you see some pretty wild flowers? Do you pick them? Or do you leave them for other people to enjoy? If you and everyone else pick the flowers, there will be no flowers for anyone to enjoy in a few years. Flowers make seeds, and seeds grow into new plants. In many states, laws have been passed to protect wild flowers that are in danger of disappearing. If you can, you should find out the names of the wild flowers that are protected in your state and learn to recognize them.

Wherever forests were cut down and bushes cleared away, many kinds of animals had no place to live. Men have also killed the wild animals and used them for food. Only about seventy-five years ago, millions of buffalo roamed the plains in the western part of our country. Today there are only a few thousand left.

Not so many years ago in our country, there were flocks of beautiful passenger pigeons. Today not one of these birds is alive. Men killed them by the thousands, and most of the forests in which they made their homes were cut down. There used to be thousands of heath hens in the eastern part of our country. Today there is not one heath hen left.

To help save our wild animals, we have passed laws. These laws say that some animals may be hunted only a few days every year. The laws also tell just how many animals each hunter may kill. Ducks, geese, pheasants, bears, and deer are some of the animals that are protected by laws.

Some animals have become so scarce, or they are so helpful to us, that the laws say that no one may ever kill them. In most states, it is against the law to kill songbirds or birds that eat mostly insects. It is also against the law to take birds' eggs.

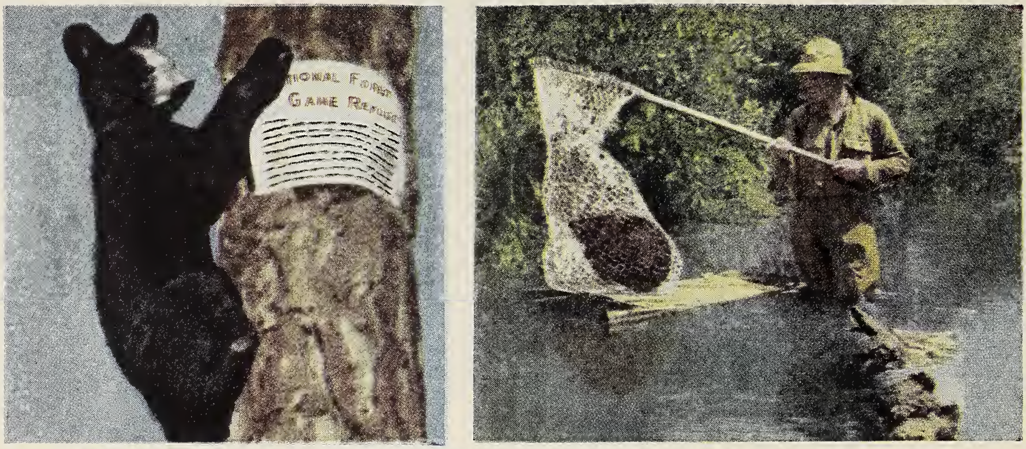
Men and women who want to conserve our wild animals have helped them find homes for themselves. In many places in our country, there are forests and swamps where no one is allowed to kill any kind of animal. Here the birds and other animals are safe to make their homes.

You can help the birds near your home by planting trees and shrubs in which they can make their nests. You can also put up birdhouses and feeding stands. You will be surprised when you see how quickly the birds learn to come for food.

---

1. *What does* conservation *mean?*
2. *Tell three things that are being done to save our forests.*
3. *How can you help conserve our forests?*
4. *What are we doing to protect wild animals?*
5. *What is causing many of our wild plants and animals to disappear? What can you do to prevent this?*

Leaving grass and bushes around the edges of fields and along roads makes places for birds like this grouse to build their nests. These 4-H Club boys have raised this young deer and are letting it go in the forest.



If this bear cub could read, it would know that it is safe from hunters. The man in the other picture is catching a beaver. He wants to take it to another place where some beavers are needed to make a dam in a stream.

QUESTIONS TO ANSWER

1. Why is it important to find out what foods wild animals eat?
2. What is the most important way in which plants and animals help each other?
3. Why do animals need plants more than plants need animals?
4. Why can people use plants and animals in more ways than any other kinds of living things can use them?
5. Why do farmers plant corn, potatoes, and tomatoes in rows several feet apart instead of scattering the seeds around everywhere?
6. In some parts of the world, there are forests so thick that small plants cannot grow on the ground. Why can the small plants not grow?
7. Name some plants and animals that need our protection.

THINGS TO DO

1. Find out how these animals are helpful to us—sea gulls, skunks, snakes, and toads.
2. Write to your State Department of Conservation and find out what your state does to keep a supply of fish in the lakes and streams.
3. Read more about bees and ants.
4. Make a report to your class to show that
   a) Animals cannot live without plants.
   b) Plants are helped by animals.
   c) People need plants and animals.

5. Make a collection of pictures that show different ways in which we use animals and plants.

6. Ask a druggist or a doctor to tell you about some of the plants that are used in medicine and some of the drugs that are made from plants.

7. Make a list of rules that we should follow to protect trees.

8. Read about the life of beavers.

9. Try to find examples of how animals live together and report what you find to your class.

10. Make some birdhouses and put them up near your home and school. Keep a record of the birds that nest in them.

11. Make a collection of plants that have been harmed by insects.

12. Write to your State Department of Conservation to get a film on forestry to show in your school.

13. Find out why mosquitoes made it very hard to build the Panama Canal.

14. Write to your State Department of Conservation and find out what animals and plants are protected by law in your state.

15. Find pictures of protected plants and put them on the bulletin board. Learn to know as many of them as possible.

16. Read about the social insects called termites.

17. The boys in the picture below belong to a club that works to protect the trees. Find out if there is a club like this in your state. Join it if you can.

★ *In Unit Two You Will Learn* ★

★ *Why things move* ★ *Where your muscles get their energy* ★
★ *How springs get their energy* ★ *What the greatest force in the world is* ★
★ *How we use moving water* ★ *How we use moving air* ★
★ *Why steam can move things* ★ *How we use the force of explosions* ★
★ *How electric current moves things* ★
★ *How one form of energy can be changed to another* ★

UNIT 2

What Makes Things Move?

SUPPOSE YOU wake up some morning, and nothing on earth is moving except you. You look at the clock to see what time it is. But the clock has stopped. You go into the bathroom to wash. When you turn on the faucet, no water comes out. Then you have to eat a cold breakfast, because gas does not come through the pipes into the kitchen stove.

You start for school on your bicycle. When you come to the hill where you usually coast, something strange happens. Instead of coasting downhill, you have to keep on pedaling!

When you look around, you see something else that is strange. All the automobiles, streetcars, and busses are standing still. There is no wind. The air is not moving. Even the water that used to flow swiftly under the bridge is as still as can be. Nothing is moving but you!

Of course, this could not really happen, because things are always moving. Clock hands, water in faucets, gas in pipes, bicycles, cars, and hundreds of other things around you all move. Do you know what makes things move? This unit will help you find out.

Why do things move?

IF YOU WANT to move a chair, you can either pull the chair or push it. Perhaps you think that lifting a chair is different from pulling it or pushing it. But if you will lift a chair, you will see that you are really pulling on it. Nothing moves unless something pulls or pushes it. Scientists have a word that means a pull or a push. This word is force. Whenever anything in the world moves, it is moved by some force.

All around you, forces are moving things. Water is flowing downhill. The trees are moving in the wind. Baseballs are thrown or batted through the air. You are walking or running to school. Automobiles, streetcars, and trains are moving on the ground. Airplanes are flying through the air. Water wheels and windmills are turning. In every one of these examples, a force is moving something.

Read over the examples. You will see that the forces which move these things are produced in different ways. You use your muscles to move yourself and other things. Automobiles and airplanes use gasoline engines. Trains use Diesel engines or steam engines. Streetcars use electric motors. Windmills use the force of moving air. Water wheels use the force of moving water.

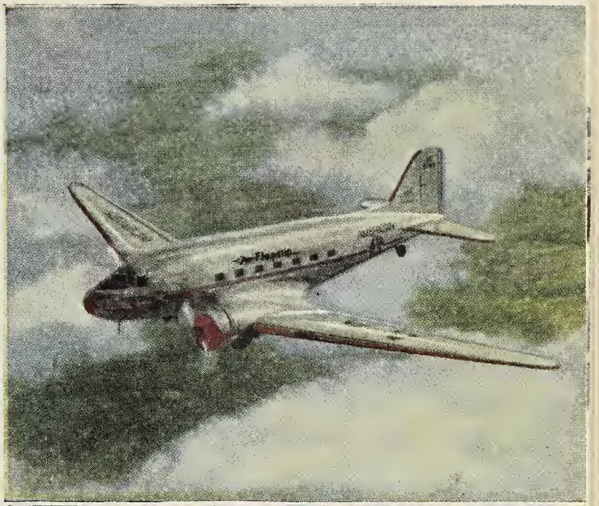
Muscles, engines, motors, water wheels, and windmills can all push or pull things. They can make other things move. They can do this because they have energy. Without energy, there would be no force.

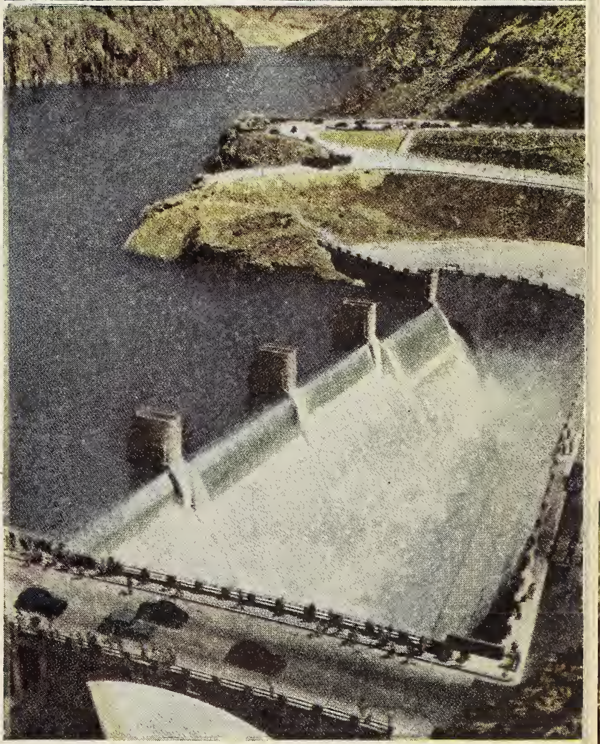
Scientists say that energy is the ability to do work. Let us see what this means. Your muscles can move your arms and legs and other parts of your body. They can do this because they have energy stored in them. You can use the energy stored in your muscles to pull back a bow. When you let the string go, the arrow will fly through the air. The bent bow can make the arrow move through the air when you let it go. It can do this because the bow has energy in it after it is pulled back.

You can use the energy of your muscles to wind a spring in a toy. When the spring unwinds, it will drive the toy across the floor. The wound-up spring has energy in it. A moving automobile has energy in it. If it strikes another car, it will move the car. The water falling over a dam onto a water wheel many feet below has energy. The moving water makes the wheel turn when it strikes the wheel. A strong wind has a great deal of energy. It can move boats or even blow a building down.

Now you can see what we mean by energy. In every example you have read where a force was moving something, there was also energy. This energy was in the muscles, the moving air, the moving automobile, the bent bow, and the water above the dam. It is the energy in all these things that makes force possible. Without energy, there would be no force. So whenever you see some force moving something, you know that this force is produced by energy.

As you can easily see, there are different forms of energy. The energy stored in your muscles is one form of energy. When an electric motor is turned on, the motor will run. Elec-





tric current makes the motor run. So electric current must have some form of energy. The energy that things have when they move is another form of energy.

As you study science, you will learn a great deal about energy and about the different forms of energy. Remember that every force is supplied by some form of energy.

Now you can probably tell what happened in the imaginary story on page 45. What must have happened if nothing moved?

---

1. *What is a force? Give some examples of forces.*
2. *What do we mean by energy? How can you tell when something has energy?*
3. *Which of these have energy? How do you know?*
   - *Stretched rubber band*
   - *Moving baseball bat*
   - *Electric current*
   - *Wind*
   - *Water coming from a faucet*
4. *Where does a ball get the force that will break a window?*
5. *What would happen if all forces suddenly disappeared?*

Where do your muscles get their energy?

YOU HAVE LEARNED that your body is moved by your muscles. When your muscles get shorter or longer, they move the bones of your body so that you can walk, run, play, write, lift a book, and move your body in many ways. Your muscles can move your body because they have energy.

Do you know where your muscles get the energy to pull and push and lift? If you remember what you learned about your body, maybe you can tell. And if you should go without food for three or four days, you would know where your muscles get their energy. Perhaps you have read stories of people who were lost for days without food. You know they became so weak that they could not walk or even call for help.

The energy that your muscles have comes from the food you eat. A glass of milk, an apple, and a piece of meat cannot move by themselves. But your body changes them so that they give energy to your muscles. Then your

What form of energy is being used in this picture?

muscles can move your body. And you can throw things, lift things, and make things move in other ways. Every living thing must have food, or it cannot move itself or any part of itself. Food has energy stored in it. Later in this book, you will learn where food gets its energy.

A long time ago, people did not know about the different forms of energy. The only energy that they could use was the energy stored in their muscles. After a time, they began to use the muscles of animals to help them. Animals were trained to pull wagons, carts, and plows, and to carry loads on their backs. Horses and oxen pulled plows over the fields and wagons along the roads. Even dogs were used to carry or pull loads.

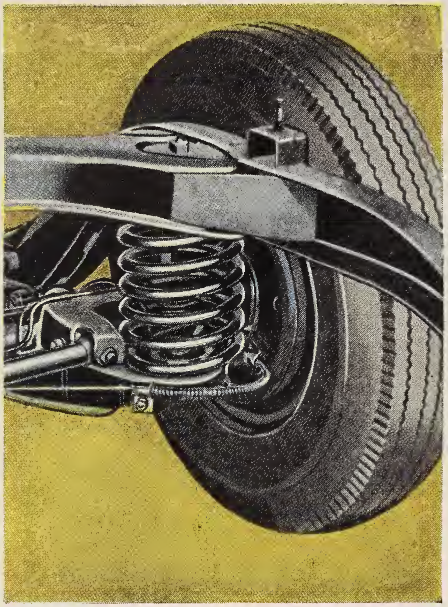
Do we still use these animals to move things?

We can move things faster and easier today because we have learned to use other forms of energy to produce forces. Then we can use these forces to move things. Later in this unit, you will learn how we do this.

---

1. *Where do we get the energy that moves our bodies?*
2. *Where do animals get energy?*
3. *Does your breakfast help you ride a bicycle? Why?*

How do springs get their energy?



If you have ever played with a toy that you had to wind up to make it go, you have used a spring. Every time you wind a watch or a clock, you are also using a spring.

A spring is usually made of a flat steel ribbon or a steel wire. The steel ribbon or wire has no energy. It cannot push or pull. But if you change it in some way, the spring has energy. So it can produce a force that will make something move.

You already know one way to give a spring energy. You wind it up into a tight coil. To do this, you have to use the energy of your muscles. The energy that you use is given to the spring. When the spring unwinds, it gives back about as much energy as you put into it. Then it can make something move.

Not all springs get their energy by being wound up. Some get energy when they are pushed in or pulled out. The picture on this page shows one of these springs. It is used to give you a smoother ride in an automobile. Do you know how it does this?

Suppose the car hits a bump in the road. The wheel goes up and pushes the spring in. Then the spring pushes back and forces the wheel down. If the wheel goes down too far, the spring is stretched out. Then it pulls back and forces the wheel up.

You can find springs in many other places. A spring on a screen door pulls the door shut after you have opened it. Window shades have springs to help you roll them up. Springs in an automobile engine keep some of the other parts moving. We use springs in many ways to make things move.

1. *How have you used springs? Give as many ways as you can.*
2. *What are you doing to a spring when you wind it up or stretch it out or push it in?*

What is the greatest force in the world?

THE GREATEST FORCE in the world is one that pulls on you and everything else. It is pulling on you now as you read this page. It pulls on the book you are reading, and it pulls on your pencil and paper. It is pulling on everything, and it keeps on pulling all the time.

You can easily see what this force does if you let go of your pencil. It will fall to the table or to the floor. As long as you hold on to it, it will not fall. But as soon as you let go of it, this force will pull it down. The same thing happens when you jump off a chair. The chair will hold you up as long as it is under you. But if you jump off, this force will pull you down. Do you know what this force is? It is called the force of *gravity.*

It is the force of gravity that pulls things down to the earth. Unless things are held up in some way, they will always fall from higher places to lower places. Rain falls from the clouds, apples fall from trees, and balls thrown high in the air always fall back to the earth again. The force of gravity is always pulling on things. If you want to keep a thing from falling, you must hold it or put it on something.

The force of gravity pulls you and your wagon or sled downhill. After

What force is pulling these children downhill on their skis and sleds?

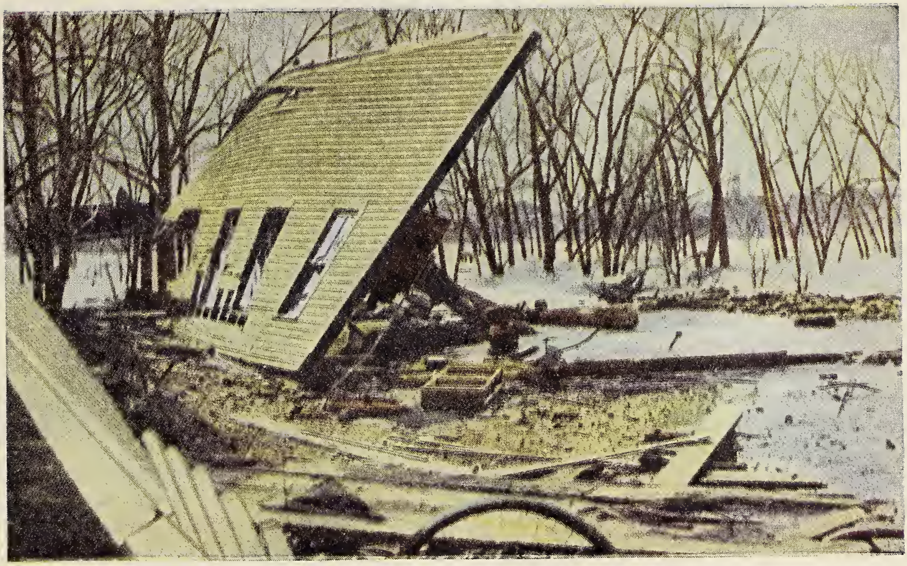
you have pulled it up the hill, you point it toward the bottom and then sit down on it. Someone gives you a little push, and away you go! Gravity is pulling you faster and faster until you get to the bottom of the hill.

Aviators who have to get out of their planes when they are in the air, use gravity to get themselves down to earth. But gravity would pull them down too fast unless they used a parachute. Later in your study of science, you will learn how a parachute works.

Do you know how much the force of gravity pulls on you? There is an easy way to find out. All you need to do is weigh yourself! The pull of gravity on you is your weight. When you weigh anything, you are really measuring the pull of gravity on it. We use scales to weigh things, and we measure their weight in pounds.

---

1. *Name the things in your schoolroom that are pulled by the force of gravity. Remember that anything that has weight is pulled by gravity.*
2. *How many of these things are pulled by the force of gravity?*
   Feather   Rock   Noise   Pail of water   Sunshine
3. *Why does the water sink into the ground after a rain?*
4. *When you weigh yourself, what are you finding out?*
5. *Which of these sentences is not correct?*
   - a) *Gravity makes rivers flow.*
   - b) *Gravity does not pull on a book if the book is on a table.*
   - c) *Rain falls because gravity pulls it.*
   - d) *Sleds go downhill because snow is slippery.*
   - e) *Gravity pulls on everything all the time.*



How do we use moving water?

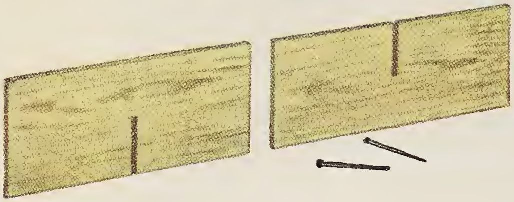
If you have ever stood in a swift stream of water, you have felt the force of the water as it raced past you. Perhaps it had enough force to push your feet out from under you. Moving water is another force that people learned to use long ago.

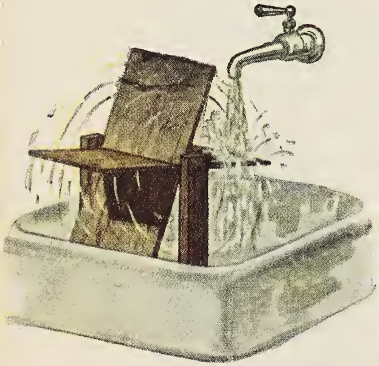
Terrible floods show us that moving water has great force. On this page, there is a picture of a building that was wrecked by a great flood of water. Do you see what happened to the building? It was lifted up, tipped over, and smashed by the force of the water. Mud and parts of other buildings were carried by the water.

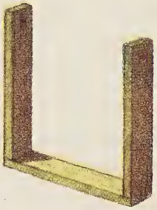
But the force of moving water does not always do harm. On the next page there is a picture that shows how people have learned to use the force of moving water to run a machine in a mill. Can you see what makes the water wheel go?

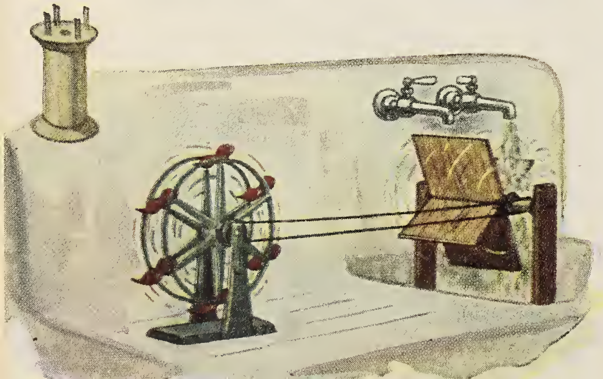
It is turned by the force of the moving water in the stream. The water moves against the paddles of the wheel and pushes the wheel around. When the wheel turns, it moves a machine in the mill. The machine grinds corn into meal and wheat into flour. The miller is using the force of moving water to do his work.

Some kinds of water wheels are used to turn machines that produce electric current. The water strikes the paddles of the wheel, and the









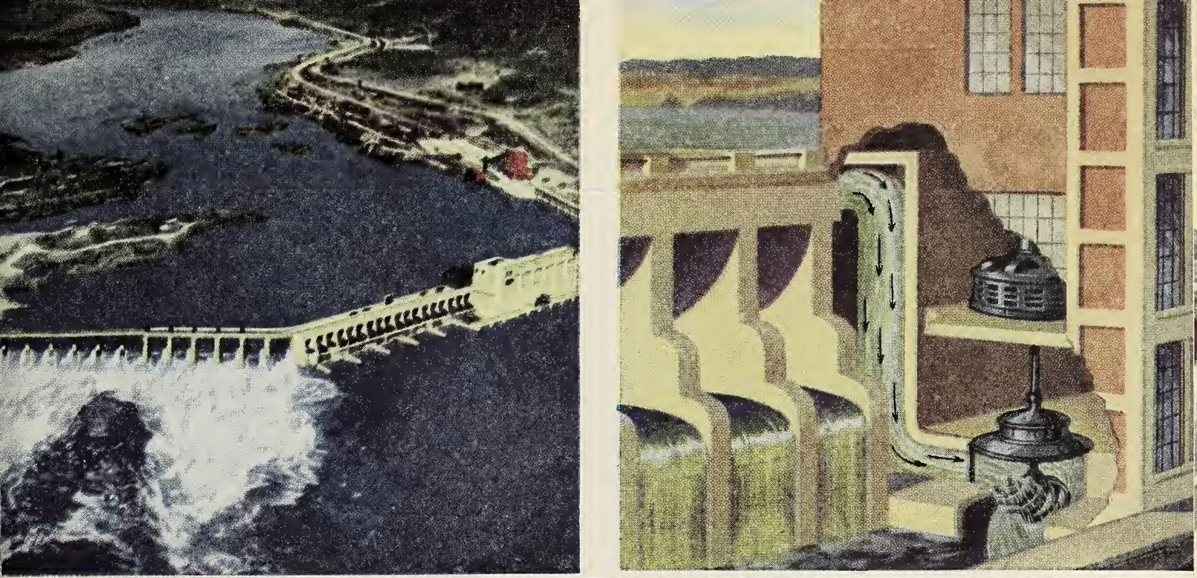
wheel turns the machines. Perhaps the electric current that lights your home and school is produced when water moves a water wheel.

You can easily understand how the force of water can make things move if you make a water wheel and watch it turn. Look at the pictures on this page. They show a kind of water wheel that you can make. Get a thin board and cut it into pieces to make the paddles. Then fasten the paddles together as they are in the picture. Put the nails through the holes in the support and hammer them into the paddles.

When the wheel is finished, hold it under a faucet and let the water fall on the paddles. Does the wheel turn? Open the faucet wider so that the water will run faster. Does the wheel turn faster? When the water runs faster, it has greater force. And when the force is greater, the wheel turns faster.

If you have made your water wheel carefully, you can use it to turn another wheel. Slip a small spool over one of the nails and fasten it to the paddles. Look carefully at the picture. You will see how the spool is connected with the small wheel on the toy Ferris wheel by a strong piece of string. Now you can see how the force of moving water can be used to make machines go.

The water that turns a water wheel would never move unless something



The picture on the left shows a big dam. At the right, you see the inside of the building where the water that falls over the dam turns the water wheel.

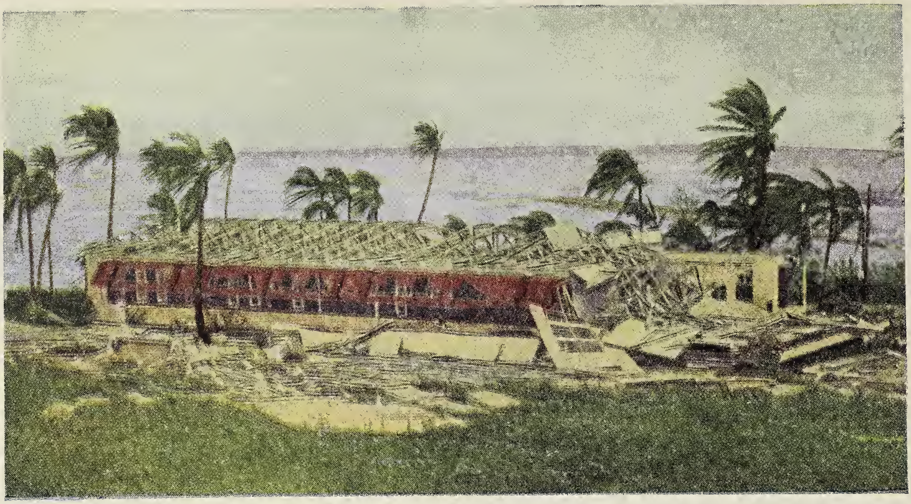
pulled it or pushed it. It is pulled by the same force that pulls your wagon or sled downhill. This force, you remember, is gravity. The force of gravity makes water run from high places to lower places everywhere on the earth.

When people built a mill near a waterfall, they used the force of gravity to turn the water wheel. The water from the top of the falls flowed over the top of the water wheel. The wheel had buckets around its rim. The water fell into the buckets, and the weight of the water in the buckets made the wheel turn.

People often make the water in a stream rise to a higher level so that when it falls, it will have greater force. To do this, they build a dam across the stream to hold the water back. The water from the top of the dam falls swiftly down through a big pipe. At the bottom of the pipe, there is a water wheel. The water falls on the water wheel with a great deal of force and makes the wheel turn fast.

---

1. *Which water wheel will turn faster, one that is in a stream flowing down a mountain or one that is in a stream on almost flat land? Why?*
2. *Why were factories often built near rivers?*
3. *Do you think that moving water has energy? Explain your answer.*
4. *How is gravity put to work by water wheels?*

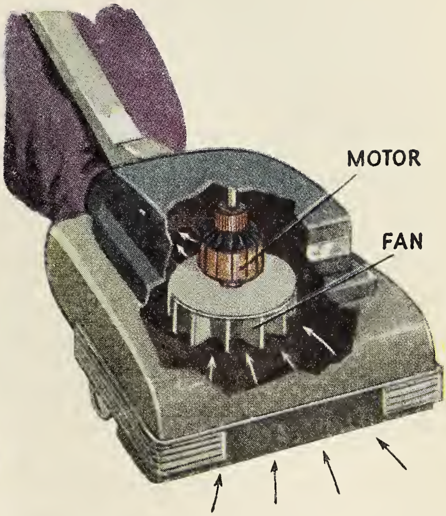


How do we use moving air?

THE FORCE of moving air did all the damage in this picture. The moving air was a very strong wind called a *hurricane.* Do you see that the roof of the building was torn off and that some of the walls were blown down? Do you think that the air still had much force when the picture was taken? How do you know?

Sometimes strong winds blow across dry fields. They lift the fine bits of soil into the air and make huge dust storms. Much good farm land has been ruined in this way. The force of the moving air may carry thousands of tons of soil for hundreds of miles before the dust settles to the earth again. Of course, a gentle wind does not have so much force. It may move only the leaves of the trees or blow dust into your home.

The first way people used the force of wind was to make their boats move on the water. Long ago, before people knew how to make engines, many boats were pushed by the wind. These boats had big sails on them. When the wind blew over the water, it pushed against the sails and moved the boats along. If the wind blew hard, the boats moved fast. But if the wind blew gently, the boats just drifted slowly along. The force of wind is also used to push boats over the ice. The wind sweeps over the frozen lake, pushes against the sails, and sends the iceboats sliding over the smooth ice at great speed.



You may want to make a sailboat and take it to a pond to let the wind sail it. Another thing you can do is to make a pinwheel. If you fasten it on the window sill or on the top of a fence, the force of the wind will keep it turning much of the time.

Moving air can push against things with great force. But the air is not always moving. Sometimes the wind blows, and sometimes it does not. You would probably like to know what makes the wind blow. Some force must make the air move. This force is gravity. Later on, you will find out how gravity makes air move.

Sometimes we make air move by using fans. A vacuum cleaner is a machine that works by using moving air. Here is a picture of the inside of a vacuum cleaner. Do you see the fan? An electric motor turns the fan, and the fan makes air rush into the cleaner. If you put your hand near the opening of the cleaner, you can feel the push of the air as it rushes in.

When the cleaner is pushed across a rug, the air rushes in with so much force that it carries the dust and dirt along with it. The air goes out through the bag of the cleaner, but the dust and dirt cannot get through. They stay in the bag.

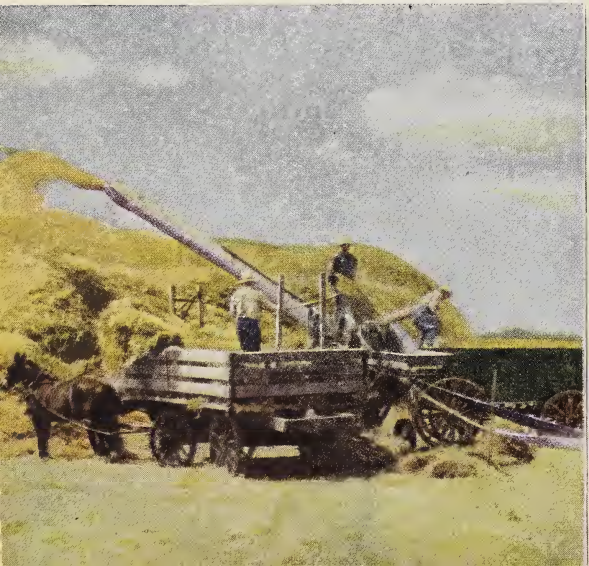
You already know that we can make air move by using fans as in a vacuum cleaner. People sometimes use air to move things through pipes. In some factories, fans blow air through big pipes. Cotton, wool, and other light materials are put in the pipes and moved from one part of the factory to another by rushing air.

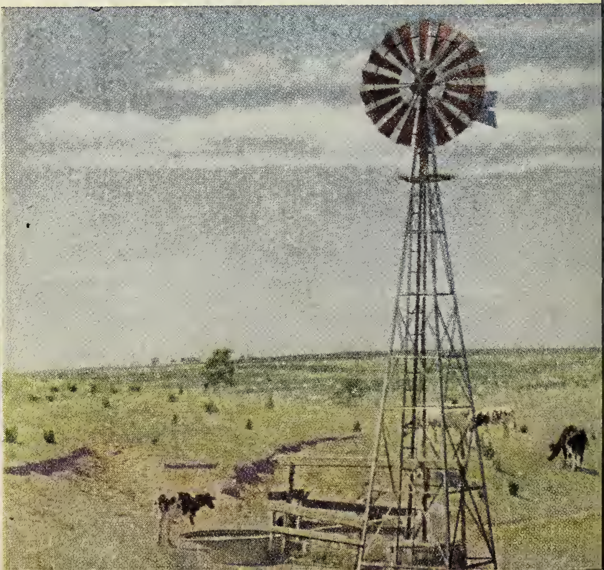
If you live on a farm, you have probably seen a threshing machine. It separates the grains of wheat or oats from the straw. Then a big fan sends air through a long pipe to blow the straw out onto a big pile. In the picture at the left on this page, you can see the straw being blown out of the pipe. The other picture shows how the force of moving air is used to keep a tank filled with water so that the cows can drink. The wind turns the wheel of the windmill. The wheel works a pump that brings water up from a well. People have used the force of wind to run windmills for hundreds of years.

Moving air is like moving water. We can use its force to make many things move.

---

1. *In which of these ways is the force of moving air like the force of moving water?*
   - a) *It may be very strong.*
   - b) *It may be used to help us.*
   - c) *It may cause damage.*
   - d) *The faster it moves, the more force it has.*
   - e) *It can move very heavy things.*
2. *If you wanted to get to a place at a certain time, would you rather take a boat that is run by an engine or one that is moved by the wind? Why?*
3. *What makes the air move in a vacuum cleaner?*
4. *How do we use the force of the wind?*





Look carefully at the pictures on this page and the next one. They will help you understand how a locomotive is made.

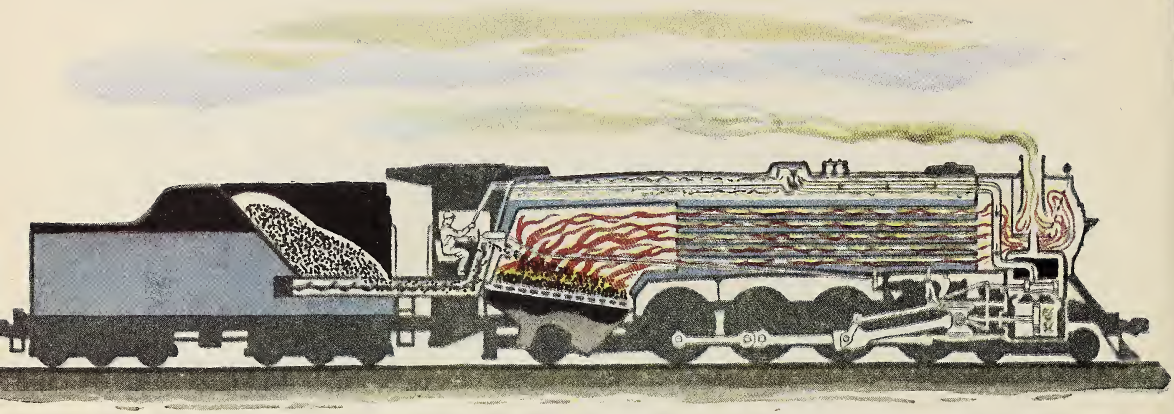
Why can steam move things?

Many times you have seen a long train of railroad cars pulled by a puffing locomotive. You know that the locomotive is called a steam engine. What force moves the engine and the long, heavy train of cars? It is the force of steam. Long after people learned to use the forces of moving air and water, they discovered how to make steam move things. When they learned how to use its great force, they could do many things that they could never do before.

Do you know where steam comes from? It comes from water. But before water can make steam, it must be heated. When water gets hot enough, it boils and changes to steam. Steam is a gas. Like air, steam is colorless. You cannot see it at all!

Probably you have watched a teakettle in which water was boiling. Steam filled the kettle and then began to come from the spout. If you looked close to the spout, you saw a little clear space. In this space there was steam. Beyond this space was a white cloud. You probably call this cloud "steam," but it is really water.

When a teakettle is full of boiling water, steam is sometimes made faster than it can get out of the spout.



Most of the locomotive is used to hold the water and the fire. Can you find the pipe that carries the steam from the boiler to the part that moves the wheels?

Then the lid of the kettle pops up and down. The force of the steam makes the lid move. An easy way to understand how steam can move things is to do this experiment.

Fill a test tube about half full of water. Put a cork in the top of the test tube. Be careful to set it lightly in the opening. *Do not push the cork in tightly.* Now heat the test tube gently. *Keep the cork pointed away from your face and away from anyone who is watching you.*

As the water boils, it changes to steam. The steam quickly fills the test tube. The water keeps on changing to steam. The steam crowds against the sides of the tube and also pushes against the cork. At last, there is so much force against the cork that it shoots off into the air. If the cork had been pushed tightly into the test tube, the force of the steam would have burst the glass into pieces.

But why does the steam have such great force? When water changes to steam, it makes a great deal of steam out of a small amount of water. If one quart of water is all changed to steam, how many quarts of steam do you think it makes? It makes 1600 quarts!

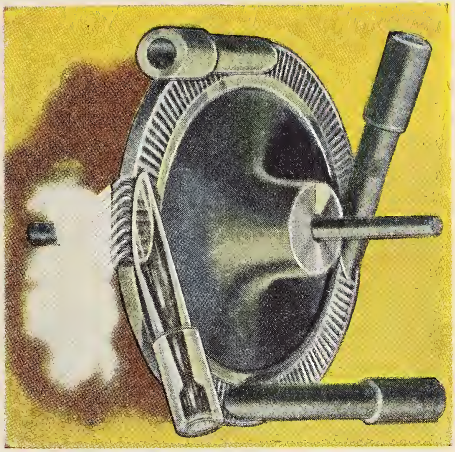
It is easy to see that 1600 quarts of steam will push hard in all directions if you try to keep it all in the same space that a quart of water takes up. You have seen the same thing happen when you pump air into a bicycle tire. The more air you pump into the tire, the harder the tire becomes.

Every steam engine has a boiler for water and a fire to change the water to steam. Pipes carry the steam to the engine. The energy that a steam engine uses comes from coal, oil, or other fuel.

Fuel is like food because it has energy stored in it. When the fuel burns, it gives off heat. Heat is energy, too. It can change water to steam. The steam can push against a part in the engine and make it move back and forth. Then the engine turns wheels to make something move.

The next time you see a steam locomotive pulling a long train of cars, you can say to yourself, "Steam gives the force that is pulling all of those cars. The coal is burning, and the heat from the burning coal is changing the water to steam. The steam is pushing hard to get out. This push makes the wheels of the locomotive turn. The locomotive is just a machine for using the force of steam to move trains for us."

Another kind of steam engine turns like a water wheel or a windmill. Pipes carry steam from a boiler to a wheel. The rushing steam pushes hard against blades in the wheel, and the wheel turns very fast.



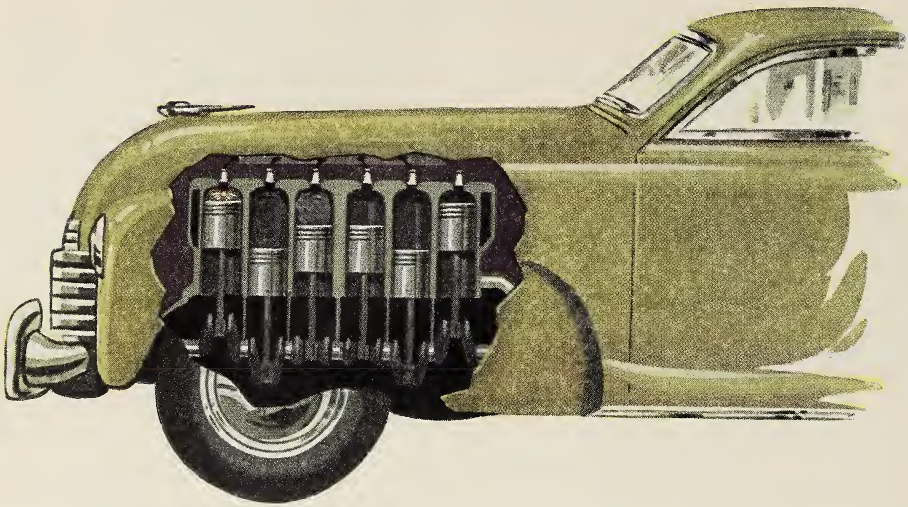
This wheel is turned by the force of the steam that comes out of the pipe and hits the blades of the wheel.

The picture above shows how this kind of steam engine works. Of course, this is just a small one. Many of the steam engines like this that run ships and power plants have many rows of blades. There may be thousands of blades. The steam pushes against all these blades so that the wheel turns very, very fast.

Steam engines are used to pull trains, to make ships move, to run big scoop shovels, and to turn the wheels of machines in many power plants and factories.

---

1. *What two things must a steam engine have so that it can get steam to make it move?*
2. *What makes water turn into steam?*
3. *Is steam a solid or a liquid or a gas? Can you see steam?*
4. *Why did steam push the cork out of the test tube?*
5. *What does steam do in an engine?*



The engine of an automobile looks somewhat like this. Look for the parts where the gasoline explodes.

How do we use the force of explosions?

DID YOU EVER travel on the force of an explosion? You may think that is a very funny question. But probably every boy and girl in your class has traveled on the force of explosions many times!

Whenever you ride in an automobile, you are being moved by the force of an explosion. Gasoline explodes inside the engine and makes the automobile move. Like coal or any other fuel, gasoline has energy stored in it. The force of the explosion comes from this energy in the gasoline. Now let us see what makes the gasoline explode.

We put gasoline into a tank on the automobile. When it is put into the tank, the gasoline is a liquid. It flows through a pipe to the engine. Then it goes through a part that changes it to a fine spray. Air is mixed with the spray, and the gasoline changes to a gas. Then the gas goes into another part of the engine. Here a tiny electric spark explodes the gas.

When anything explodes, it suddenly gets very much larger. It pushes out in every direction with great force, just as steam does. This great force can make something move. When gasoline explodes in the engine of a car, the force of the explosion moves parts of the engine. Then the wheels turn, and the automobile moves. A gasoline engine is just a

This streamlined train, which can go very fast, is pulled by a Diesel engine.

machine that is run by the great force of exploding gasoline.

Another kind of engine also runs by the force of explosions. It is called a Diesel engine. For fuel, it uses oil instead of gasoline. And no spark is needed to make the oil explode. Many ships and trains use Diesel engines.

The force of exploding gas can carry you over the roads at high speed. It can also move big, heavy trucks and boats and pull plows through the soil. It can run the engines that make airplanes fly. What a different world this would be if we did not have the force of explosions!

---

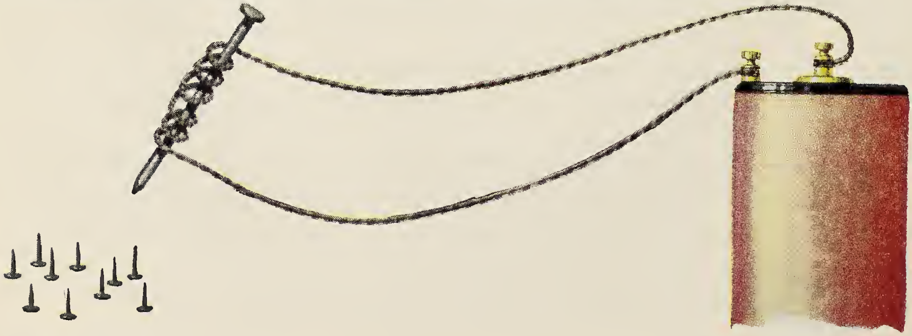
1. *What word is needed in each sentence?*
    - a) *Gasoline is a__________when we put it into the tank.*
    - b) *Gasoline is a__________when it explodes.*
    - c) *When gasoline explodes, a great__________is produced.*
    - d) *Exploding gasoline has force because it gets__________.*
2. *How are steam and gasoline alike in the way in which they produce force? How are they different?*
3. *What makes the gasoline explode in an automobile engine?*

How does electric current move things?

Here is a picture of a boy who is using the energy of electric current. His father gave him an electric train for Christmas. It must have something to make it move. The track is connected with an electric outlet by a long cord with wires in it. Inside the engine is an electric motor. When the boy turns the electric switch on, an electric current will flow through the wires, through the track, and into the motor of the toy engine. The motor will turn and move the engine that pulls the train. When he turns the switch off, the electric current stops flowing. The motor no longer turns, and the train stops.

This experiment will help you understand how a motor works. Get a large iron nail. Wind about twenty turns of cotton-covered copper wire around the nail. Now connect the two ends of the wire to an electric *cell,* as shown in the picture below. Try to pick up some tacks with the nail. Is the nail a magnet? What happens to the tacks on the nail when you disconnect one wire from the cell?

The experiment shows that an electric current flowing through a wire around a nail will make the nail into a magnet. When the current is stopped, the nail is not a magnet.



You can make a motor turn by connecting it to some electric cells.

Look at the picture of the motor. The frame of the motor is made of iron. The two sides of the frame are connected at the bottom with a piece of iron. It has some wire wound around it. When an electric current flows through the wire, the frame becomes a magnet. Magnets, as you remember, have poles. One end of the iron frame is a north pole or N pole, and the other end is a south pole or S pole.

Now look at the part that turns inside the frame. It is made of iron, too. It also has wire wound around it. When an electric current flows through the wire, this part becomes a magnet, too.

When you studied magnets, you learned that *like* poles always *repel* each other and *unlike* poles *attract* each other. Try this experiment. Tie a string around a bar magnet and hang it from a wooden support. Hold another bar magnet in your hand and bring the end marked N near the N pole of the hanging magnet. What happens? Now, as the magnet turns halfway around, bring the S pole of the magnet in your hand near the S pole of the hanging magnet. If you keep on doing this, you can make the hanging magnet turn round and round.

An electric motor works in the same way. The electric current makes the frame a magnet, and it also makes the part that turns inside the frame a magnet. This part keeps turning as the like poles of the two magnets repel each other and the unlike poles of the two magnets attract each other. If you have a small electric motor, you can connect it to some cells to make it run. Look at the picture on this page. It shows you how to connect the cells and the motor.

Your mother may use electric current to keep your clothes clean. She does if her washing machine is run by an electric motor. If her sewing machine is an electric one, there is a motor to move the needle up and down when she sews. There is a

The energy of moving water is keeping Betty cool! If you look at these pictures and read the next page, you will see how this can be true.

motor in her vacuum cleaner. If you live in the city, you may ride on streetcars run by electric motors. If you live in the country, you may use a motor to pump water from the well up into a big tank.

People have invented a machine that makes electric current flow through wires. This machine is called a *generator*. A generator may be run by water wheels, steam engines, gasoline engines, Diesel engines, or by the wind. Look at the pictures on page 55. The water wheel at the bottom of the dam is running a generator that makes electric current flow. In the picture on page 68, the generator is run by the wind. In an automobile, there is a little generator for making electric current flow. The current from this machine makes the spark that explodes the gasoline.

The second way of making electric current flow is with an electric cell. When we connect two or more cells to get current, we say that we have an electric *battery*. When you push down on the starter of an automobile, an electric current from a battery runs a motor. This makes the automobile engine turn until the gasoline begins to explode and run the engine. The cells of the battery have energy stored in them. This energy makes an electric current flow when the battery is connected to a motor. The electric current has energy that gives the force to turn the motor.

---

1. *What are two ways to make electric current flow?*
2. *How do we know that an electric current has energy?*
3. *Name some machines that are run by electric motors.*

The electric current that comes from the generator goes through several wires before it comes into Betty's house.

How can one form of energy be changed to another?

DO YOU BELIEVE what it says under the pictures on page 66? Of course, there is no moving water in that picture. Then how can Betty be using the energy of moving water?

The electric fan is moving the air around Betty. It is moving her dress, the window curtain, and even her hair. This moving air is keeping her cool. Would you believe that Betty is being kept cool and that her dress is moved by the energy of moving water?

Betty's home is a few miles from a river that has a big dam in it. The rushing water falls over the dam and runs generators that make electric current flow through wires. The current flows through several wires until it comes to Betty's house.

Betty has connected the electric fan to the electric outlet in her room. This connects the fan with the wires that carry the electric current from the generators. Inside the fan is an electric motor. The energy of the electric current gives the force that makes the motor turn. The turning motor moves the fan. The whirling fan blades strike the air and make the air move. So you see how Betty is being kept cool by the energy of moving water.

This shows you a very important thing about energy. One form of energy can be changed into another form of energy. This change of energy from one form to another is taking place all around you. What are some ways in which it is happening?

If you read this unit over again, you will find many examples of this change of energy. In your body, the energy stored in food is changed into the energy your muscles have.

The energy of moving water can be changed into the energy of electric current. So can the energy of moving air, as shown in the picture. This wind generator can make enough electric current for a small village.

When a steam engine moves, it is using the energy in steam. This comes from the energy stored in coal, oil, or some other fuel. When the fuel is burned, it gives off heat. Heat is also a form of energy.

An automobile engine gets its energy from gasoline. The stored energy in the gasoline is changed into a form of energy that can move the car. This happens when the gasoline explodes in the engine.

Whenever you see something move, you can be sure that somewhere some form of energy is producing the force to make it move.

---

1. *How could explosions keep you cool?*
2. *How could a coal fire keep you cool?*

QUESTIONS TO ANSWER

1. Which of these helps you most in your home? Moving air, electric current, steam. What are the different ways in which it helps you?
2. How are moving water, steam, electric current, and moving air all alike?
3. How does the force of gravity help us? How does it hinder us?
4. Which of all the forms of energy do you think helps us most? Why do you think so?
5. How do these men use the forms of energy you have learned about? A dentist, a farmer, a railroad engineer, an automobile repairman.
6. Study the picture on page 58. What forces are being used?

THINGS TO DO

1. Visit a place where water is being used to make electric current. Find out where the water wheel is.

2. Find out how many forms of energy your father uses to do his work.

3. Find out what form of energy is used to produce the electric current in your home or town.

4. If you have a toy steam engine, bring it to school. Run the engine to show that steam has force.

5. Write a story that tells how the world would be different if electric current, steam, gasoline, and moving air did not have force to make things move.

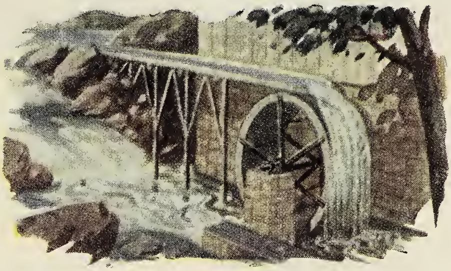
6. Make a list of things that you have seen being moved in the last few days.

7. People move things by exploding other materials besides gasoline. Find out

a) How big blocks of stone are broken loose in stone quarries.

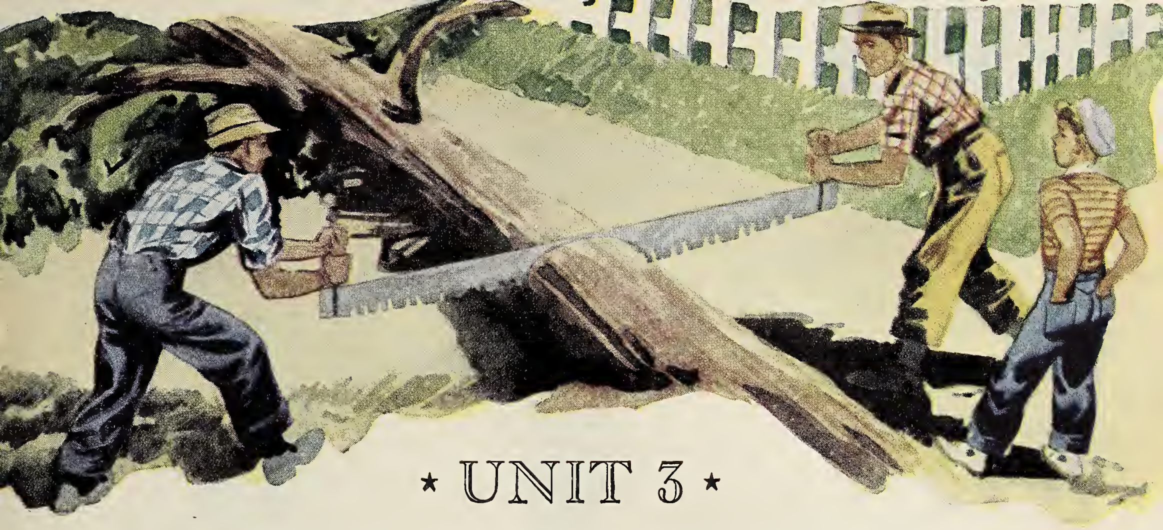
b) What makes a bullet shoot out of a gun.

8. If you can, look at a steam locomotive and find out how the force of the steam is used.



★ In Unit Three
You Will Learn ★

★ *What a machine is* ★ *How we use levers* ★ *How we use inclined planes* ★ *How we use pulleys* ★ *How we use a wheel and axle* ★ *How one wheel can turn another wheel* ★ *How we can make machines work better* ★ ★ *How we can use machines safely* ★



★ UNIT 3 ★

How Is Our Work Made Easier?

One stormy night, Jack was suddenly wakened by a loud, cracking noise. Then he heard something crash outside in the yard. Jumping out of bed, he ran to the window. It was just beginning to get light. There on the ground he could see a big tree lying across the driveway to the garage. A strong wind had blown it down.

"Well," said Jack's father as they looked at the tree that morning, "I can't get the car out until the tree is moved. It's too heavy for us to do. I'll have to get some men to move it."

"How can they move a big, heavy thing like this?" Jack asked. "It will take a lot of men to lift it. And if they try to drag it off, the branches will ruin our lawn."

"Wait and see, Jack," laughed his father. "The men will probably be here this afternoon."

That afternoon, Jack hurried home from school. The men were already working. It was fun to watch them. First, they chopped off all the branches with axes. Next, they used a big saw to cut the tree into short logs. Then with wedges they split the logs into smaller pieces. Jack could lift some of these pieces himself. He helped the men pile them up.

Now Jack saw how a few men could move a big, heavy tree. They used tools to make their work easier. Tools are helpers. They help us make better use of the force of our muscles and of the other forces you read about in Unit Two. Many times every day, we use tools and other helpers in our work. Scientists have a name for all these helpers that we use. They call them *machines*. In this unit, you will learn why many things you use are called machines.

What is being done in these pictures? How could these things be done more easily?

What is a machine?

When you think of a machine, you probably think of something like an automobile or a locomotive. They are machines. But a hammer or even a can opener is just as truly a machine as a locomotive or an automobile. You may be surprised to learn that all of these things are machines—orange squeezer, knife, wheelbarrow, broom, windmill, scissors, egg beater, pencil sharpener, bicycle. Can you tell why each one is a machine?

A hammer, a pencil sharpener, and a bicycle do not look alike. Machines have many shapes and sizes, but there is one way in which all machines are alike. Every machine can be used to make our work easier. A machine is a helper. We use machines to do a great deal of our work. They help us cut, mix, bend, straighten, lift, push, and pull things.

We can do many things with machines that we cannot do without their help. Men could not break a big tree into small pieces with just the force of their muscles. But with axes, saws, and wedges they can easily do it. Machines make work easier.

You can see this for yourself. Cut an orange in two and squeeze the juice out of one half with your hands. Was it easy to do? Did you get out all the juice? Now use an orange squeezer to get the juice from the other half. Was it easier to do this time? Did you get out more juice? The orange squeezer made your work easier, and it helped you do a better job.

Big machines and even some little machines are made of many parts. You know that locomotives, automobiles, bicycles, watches, and sewing machines have many parts. But do you know that all these machines are made of a few kinds of *simple machines* put together in different ways? In each simple machine, there are only a few parts.

If you could take a watch, an automobile, or an airplane apart, you would find the same kinds of simple machines in each one. Let us see what these simple machines are and find out how they make our work easier.

---

1. *Why do we use machines?*
2. *Name as many different machines as you can and tell how each one helps us.*

How do we use levers?

DID YOU EVER play on a seesaw? You sit on one end of a long board, and another boy or girl sits on the other end. In the middle, there is a support that holds the board up. To make the seesaw go, you push against the ground with your feet. This push lifts your end of the board and makes the other end go down. Then the other child pushes with his feet, and so on. In this way, you can keep going up and down.

You probably noticed that the seesaw works better if you balance the board first. This is easy to do if both of you weigh about the same. Each one sits at the same distance from the support in the middle of the board. Gravity pulls down on each of you with about the same force, and the board balances. It takes only a little push with the feet to make the seesaw go.

But what happens if one of you weighs much more than the other? Gravity pulls with more force on the heavier child. His end of the board comes down with a bump, and the other end flies up. To make the seesaw go, the heavier child has to push hard with his feet. The other child does not have to push at all.

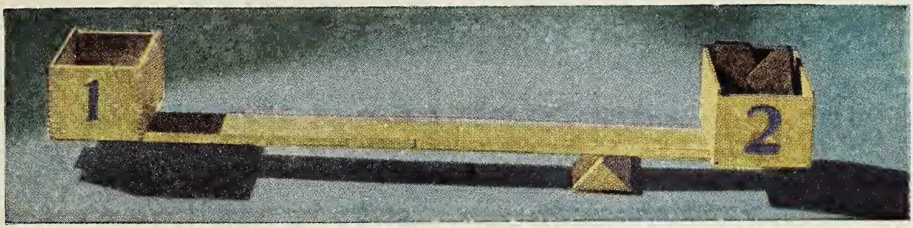
Do you know how the lighter child can lift the heavier child and make

the board balance? If there is a seesaw on your school playground, you can easily find out. Have a heavier child sit on one end of the board while you sit on the other. What happens? Now you move closer to the support in the middle. Can you lift the heavier child? Sit on the end of the board again. Then have the heavier child move closer to the support. What happens this time? Can you lift the heavier child now?

A seesaw is really a simple machine. Scientists call this kind of simple machine a *lever*. The board of a seesaw is held up by a support. This support is the *fulcrum* of the lever. Of course, most levers are not just playthings like a seesaw. We use them to make our work easier.

You can easily make a lever and do some experiments with it. Then you can see why a lever is such a useful helper. Get a board about three feet long and three inches wide. Use a small, three-sided block of wood about two inches high as a support for the board. This support is the fulcrum of the lever.

First, see if you can use this lever to make a light book lift a heavier book. Set the board on the block so that there is twice as much of the board on one side of the block as there is on the other side. One end of the lever should be one foot long and the



other end two feet long. Put the heavy book on the short end. What happens to the other end of the lever? Now set the light book on the long end of the lever. Does it lift the heavy book? Which book is closer to the fulcrum?

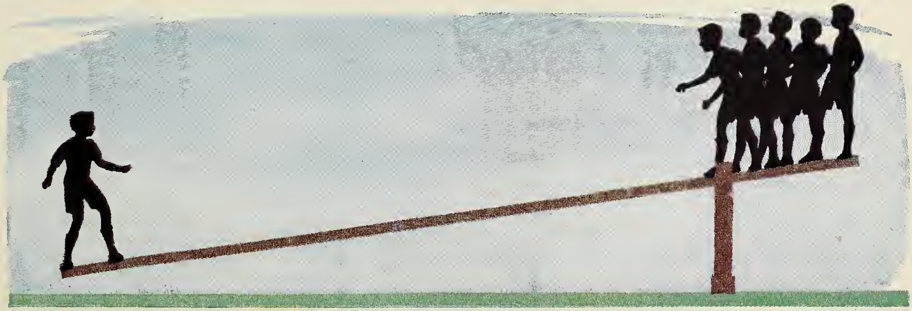
Try another experiment with the lever. Get two small boxes of the same size. Fill one box with sand, stones, or anything heavy until it weighs two pounds. Set the lever just as you had it before. Put the box that weighs two pounds on the short end. Then set the empty box on the other end. Put sand or stones in this box until it lifts the other box.

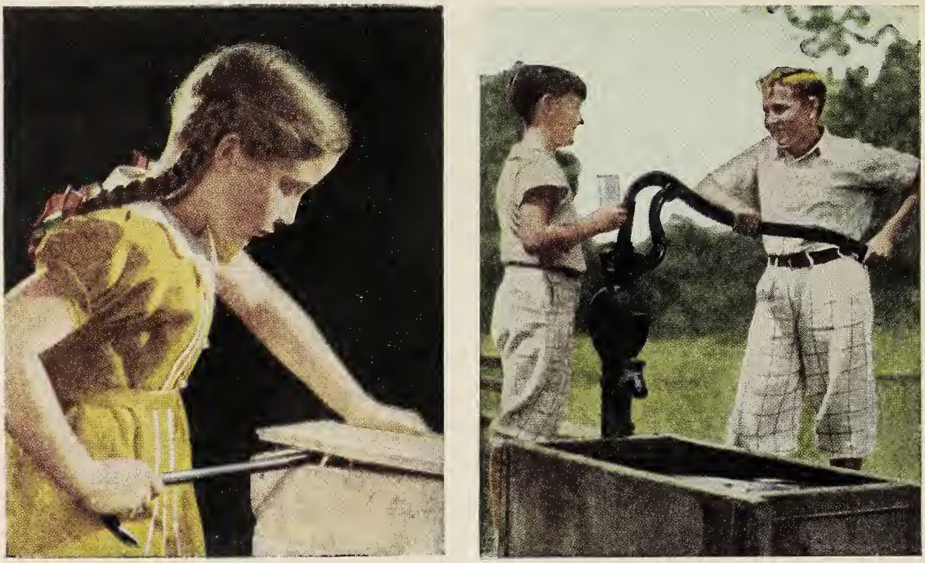
Take the box off the long end of the lever. How much does this box weigh? Is it lighter or heavier than the two-pound box? Which box was closer to the fulcrum? What does this tell you about using a lever?

You know that the weight of anything is really the force with which gravity pulls it down. We measure this force, called weight, in pounds. And we can measure any other force in pounds, too. When you lift a two-pound box, your muscles must pull up with a force of two pounds.

In the experiment, you found that the box on the long end of the lever weighed about one pound. So a force of one pound on the long end of the lever lifted a weight of two pounds on the short end. The weight was closer to the fulcrum than the force was. The lever increased the force.

Look at the picture below. One boy is lifting five boys. How can he do it?





How are these children using levers to help them?

A lever is very useful, because a small force on the long end will lift a much heavier weight on the short end. The lever increases the force. But did you notice another thing? It changes the direction of the force, too. With this lever you can lift something up by pushing down! It is easier to push down than to pull up.

Do you see why this is true? When you push down, the force of gravity is added to the force of your muscles. But when you pull up, the force of your muscles must pull against the force of gravity.

By using a lever, you can do things that you could not do at all without it. Drive a nail or a tack part way into a board but leave the head sticking out. Take hold of the head with your fingers and pull as hard as you can. Did the nail or tack come out of the board? Now use a claw hammer or a tack puller. Do you see how easy it is to pull the nail or tack? A claw hammer or a tack puller is a lever. The place where it rests against the board is the fulcrum.

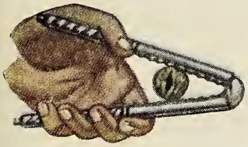
You can use a lever to lift a big, heavy stone. All you need is a strong iron bar and a smaller stone. Put one end of the bar under the big stone. Set the small stone under the bar so that the bar rests on it. The small stone is the fulcrum of the lever. To lift the big stone with the least force, have the small stone as close to it as possible. Why? Now push down on the other end of the lever. Do you see how you can lift the big stone up by pushing down?

Look at the picture of the nutcracker on this page. How does it break a nut open? Notice where the force is put to crack the nut. You push the ends of the handles together with your hands. Can you find the fulcrum? The fulcrum is the hinge at the other end. This nutcracker is a lever, but it is not the same kind as the one you used before.

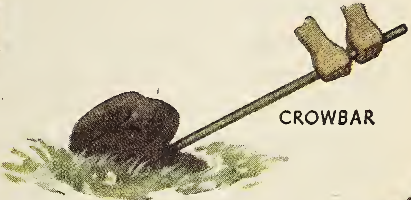
The picture of the sugar tongs shows still another kind of lever. The fulcrum is at one end just as in the nutcracker. But to close the tongs, you put the force on the sides instead of putting it on the ends. There are three main kinds of levers, but they are all alike in one way. Every lever has three parts—a fulcrum, a part where the force is put, and a part where the work is done. Look for levers at home, at school, and in other places.

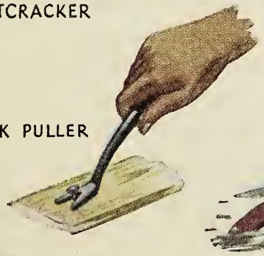
---

1. *Look at the pictures of levers on this page. Then for each lever tell where the fulcrum is, where the force is put, and where the work is done. Why is each lever useful?*
2. *You want to use a lever to lift a weight with the least force. Where should you put the fulcrum?*
3. *Tell how you can use a lever to lift something up by pushing down.*
4. *When you are playing on a seesaw with a child that weighs less than you, which one of you should move nearer the middle of the board to make it balance? If you could move the board, should you sit on the long end or the short end? Why?*


NUTCRACKER

SCISSORS

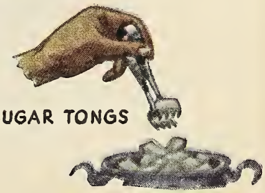

CROWBAR


TACK PULLER

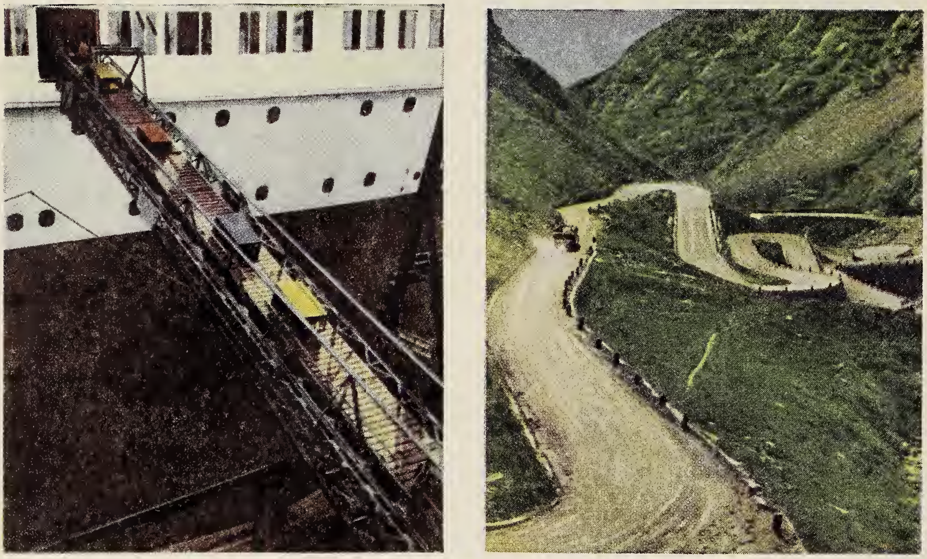
ROWBOAT

SNOW SHOVEL

BROOM


SUGAR TONGS

BASEBALL BAT



Here are two ways in which inclined planes are used. Watch to see if you can find some other ways.

How do we use inclined planes?

YOU HAVE PROBABLY watched men loading boxes and barrels into a truck. The floor of the truck is several feet above the ground. If the boxes and barrels are not too heavy, the men just pick them up and set them in the truck. But if they are hard to lift, the men use another way to get them up. One or more planks are used to make a slope from the ground up to the floor of the truck. Then the men slide the boxes and roll the barrels up the slope.

The slope made of planks is really a kind of simple machine. Scientists call it an *inclined plane.* Inclined means sloping or slanting. A plane is any flat surface. The floor of your room is a plane. So is the top of a desk or table. An inclined plane is a flat surface that is sloping or slanting. In a theater, the floor often slants or slopes. So it is really an inclined plane.

You can make an inclined plane and use it to do an experiment. Get a smooth board about four feet long and six inches wide. Near one end of a table, put a stack of books about one foot high. Let one end of the board rest on the stack of books and the other end on the table. Because the board is sloping or slanting, it is now an inclined plane.

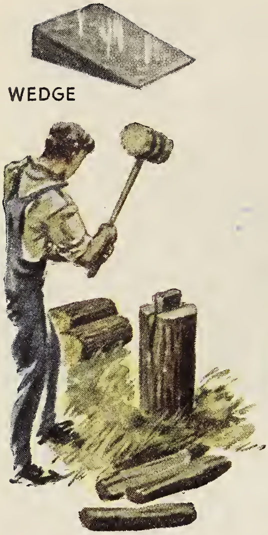
Now let us see how we can use this machine to make our work easier. Tie a strong cord around a big dictionary or any other heavy weight. Take hold of the cord with one hand and lift the dictionary from the table to the top of the stack of books. Was it hard to do?

Set the dictionary on the table again. Slip the hook of a spring balance under the cord. Then lift up on the ring and weigh the dictionary. How many pounds does it weigh? How much force did you use to lift it onto the stack of books? To lift the dictionary, you must pull up with just as many pounds of force as the dictionary weighs.

Put the dictionary at the bottom of the inclined plane. Take hold of the cord with one hand and pull the dictionary up the slope to the top. Was it easier to pull the dictionary up the inclined plane than to lift it straight up?

You can use the spring balance to find out how much force it takes to pull the dictionary up the inclined plane. Put the dictionary at the bottom again. Slip the hook of the spring balance under the cord and take hold of the ring. Now pull slowly and evenly up along the sloping board. As you pull, look at the spring balance and see how many pounds of force it takes to move the dictionary. It takes fewer pounds of force than the dictionary weighs.

If you were rolling a barrel up into a wagon, would you use a long board or a short board for an inclined plane? You can find out which is easier if you do another experiment. This time use a board about twice as long as the one you used before. What did you find out?

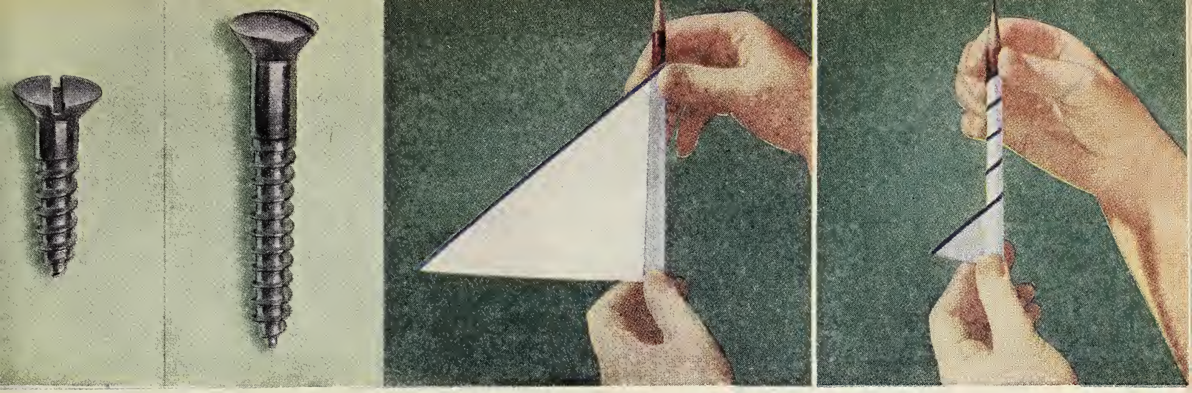


Inclined planes make it easier to lift things. When horses, cows, sheep, or pigs are loaded into railroad cars or trucks, they walk up an inclined plane. A road over a hill or a mountain is an inclined plane, too. You probably use a tool that is an inclined plane every day. Can you guess how you do this?

Every time you use a knife or any other cutting tool, you are using a kind of inclined plane. Look at the picture of the wedge. If you lay a wedge on one of its flat sides, the other flat side makes an inclined plane. How many inclined planes are there in a wedge? Now look at the pictures of the knife, the ax, and the plow. How many inclined planes can you find in each one?

Knives, axes, and plows are kinds of wedges. And a wedge is really two inclined planes joined together. If you drive a wedge into a piece of wood, the thin edge goes in first. As the thicker part follows, the wood splits sideways. When you cut with a knife or chop with an ax, the same thing happens. As a plow is pulled forward, it pushes the soil out to the sides.

You can find many other uses of inclined planes if you keep your eyes open. The sharp teeth of a saw are tiny inclined planes. Look at your own teeth, especially the ones in front that you use to bite off food. Look at the catch on a door. Can you find an inclined plane in the catch that holds a door shut?

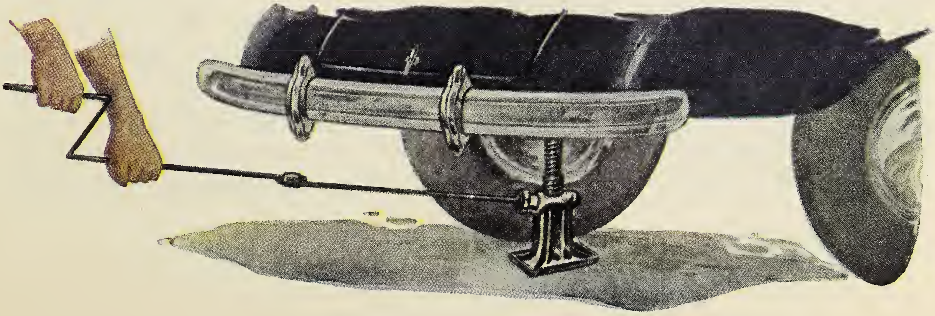


Now let us find another use of inclined planes. Look at the picture of screws on this page. A screw is really a kind of inclined plane. Take a square piece of paper and cut a three-sided piece from it. Stand this piece on one of its short sides. Do you see that the long side makes an inclined plane? Now wrap this piece of paper around a pencil, as shown in the picture. The edge of the paper makes a line around the pencil like the edge of a screw.

A screw is an inclined plane that winds around as it climbs. If you had a screw that was big enough, you could start at the bottom and walk up the winding inclined plane to the top. Because screws can pull or push with great force, we use them to hold pieces of wood or metal tightly together. A screw turned by a lever is used to make a machine that can lift very heavy weights with only a small force. This machine is called a jackscrew, or often just a jack.

---

1. *How could you show that it is easier to pull a load up an inclined plane than to lift it straight up?*
2. *Give some examples of inclined planes that you have seen being used. Tell how each one made the work easier.*
3. *Name two kinds of machines that are really inclined planes. How is an inclined plane used to make each one?*
4. *What are the two different kinds of simple machines used in a pair of scissors?*

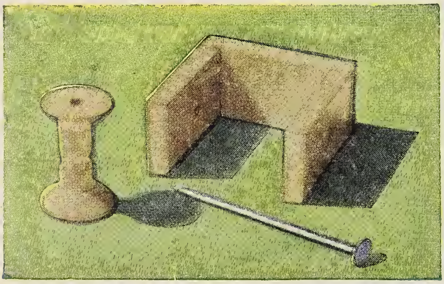


How do we use pulleys?

Can you imagine a world without wheels? You would not have a bicycle, a wagon, or roller skates. There would be no automobiles, streetcars, trains, or airplanes. Windmills, water wheels, steam engines, gasoline engines, and electric motors would not supply energy to help us do our work. To move anything, we would have to lift, drag, or shove with the force of our muscles or the muscles of animals.

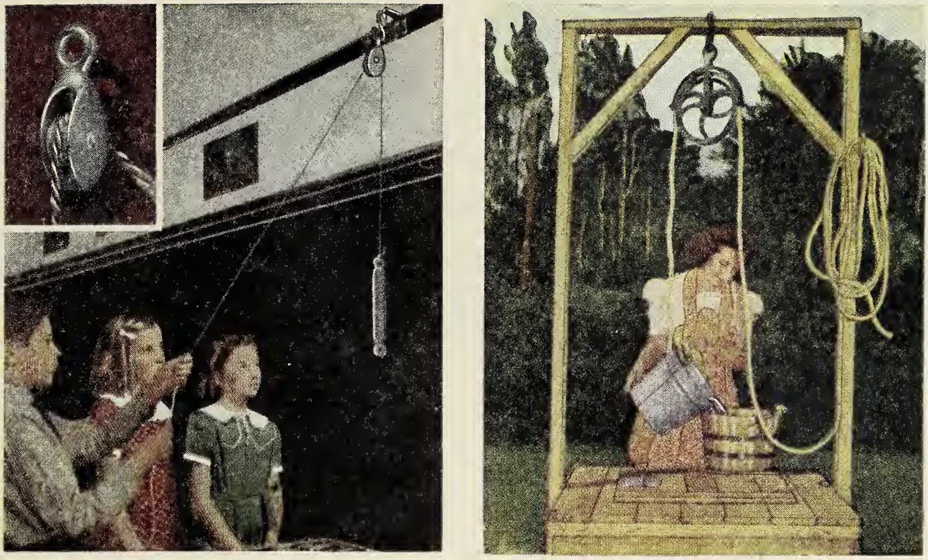
Wheels are among the most useful things ever invented. We use wheels in many different kinds of machines. Yet the Indians did not know how to make a wheel until people from Europe came to America and showed them how. There are savage tribes in Africa and Asia that know how to use levers and inclined planes. But they never use wheels. So, of course, they do not have any machines that are made with wheels.

One of the kinds of simple machines is called a *pulley*. A pulley is a wheel held so that it can turn easily. A rope or a chain or something like it goes over the wheel. Usually there is a groove in the rim of the wheel to keep the rope or chain from slipping off. Pulleys are made of wood, metal, or some other hard material.



If you do not have a pulley, you can make one. Get a strong spool and a large nail that will slip easily through the hole in the spool. Then get three small pieces of wood. Nail the pieces together, as shown in the picture. Now you are ready to fasten the spool in the frame you have made. Drive the large nail through one of the sidepieces of the frame. Put the pointed end of the nail in the hole of the spool. Then drive the nail through the hole and the other sidepiece. Put a screw eye in the crosspiece of the frame so that you can hang the pulley up.

Now you can do some experiments to see how we use pulleys. Put a hook or nail in the wall up above your head. Hang the pulley up by slipping the screw eye over the hook or nail. Put a strong piece of cord over the pulley wheel. Have the cord long enough so that both ends touch the floor. Tie any small weight to one end of the cord. Then pull down on the other end. As you pull down, the weight goes up. Like the lever you used in another experiment, this pulley changes the direction of the force.



These pictures show you how a fixed pulley is used to lift things.

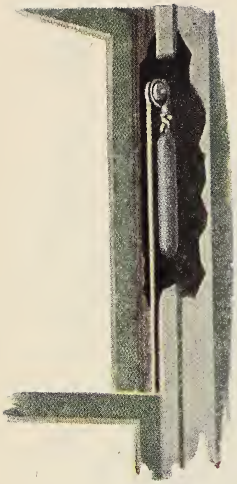
It helps us do work by moving things in one direction while we pull in another direction.

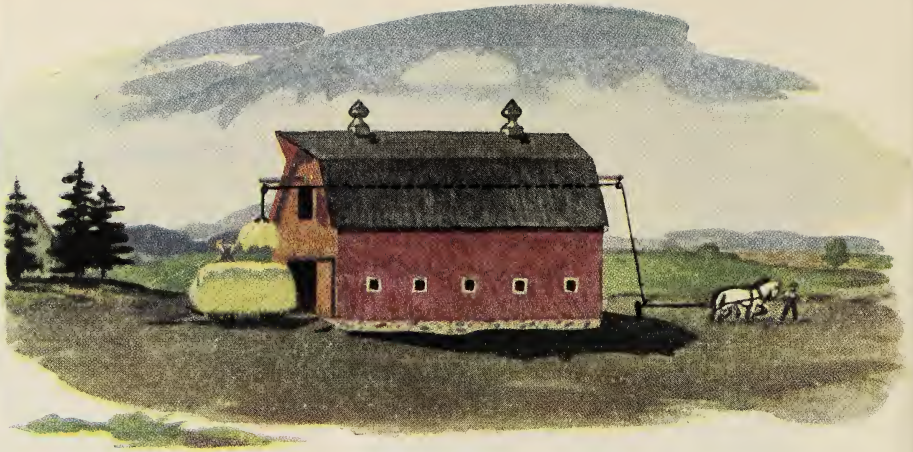
Fill a pail or basket with sand, stones, or anything heavy. Then lift this weight above your head. That was not very easy to do, was it? Use a spring balance to find out how many pounds you lifted. How much force did you use? Now see if you can lift the weight more easily by using a pulley.

Tie one end of the cord to the handle of the pail or basket. Pull down on the other end of the cord until the weight is above your head. Was it easy to lift the weight when you used the pulley? Let the weight down. Tie the ring of the spring balance to the other end of the cord. Take hold of the hook and pull down slowly and evenly. As you pull, look at the spring balance and see how many pounds of force it takes to lift the weight.

When you used the pulley, you found that it was easy to lift the weight above your head. It took as much force as without the pulley, but it was easier to do. You already know that it is easier to push down with a lever than to lift up. It is also easier to pull down with a pulley. The weight of your body helps you pull down or push down.

The pulley used in the experiments is called a *fixed pulley* because it is fastened, or fixed. It stays in one





place, and only the weight and cord move. A fixed pulley does not increase the force. But it does make our work easier by changing the direction of the force. We can use it to lift things higher than our heads by pulling down on a rope.

How does the flag get to the top of your school flagpole? No one climbs the pole. Before the flagpole was set up, a fixed pulley was fastened to the top. Then a long rope was run over the pulley wheel. To raise the flag, all you need to do is fasten it to the rope and then pull down. Up goes the flag to the top of the pole! As you pull in one direction, the flag moves in the other direction. A pulley helps us because we can lift things above our heads by pulling down.

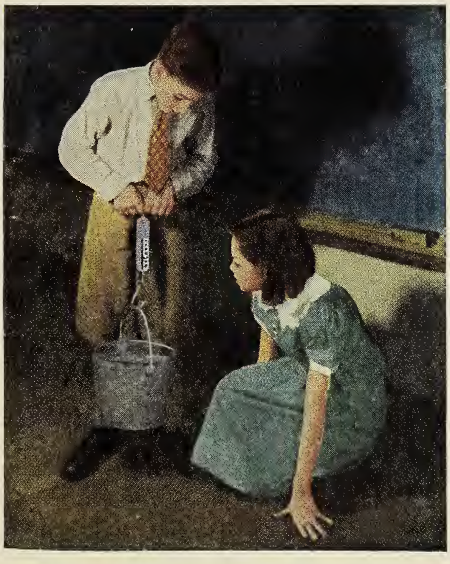
In your schoolroom, you can find another use of fixed pulleys. Go to one of the windows and lift it. The window is probably big and heavy. Why can you raise it so easily? Look up near the top of the window. Do you see pulleys on each side? Each side of the window is fastened to a rope or chain that goes over a fixed pulley. Inside the window casing on each side of the window is a weight fastened to the other end of the rope or chain. You can see the rope and the weight for one side of a window in the picture on this page. The two weights are almost heavy enough to pull the window up by themselves. It takes only a little of your force to raise the window.

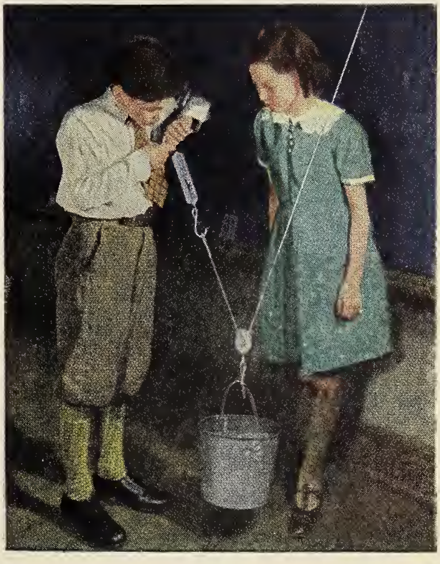
The other picture shows one way in which a farmer uses fixed pulleys to lift hay up into his barn. Near the top of one end of the barn is a pulley. On a short post just outside the barn door is another pulley. A rope goes from the horses, over the pulleys, through the barn, and down to the load of hay. When the horses pull on the rope at one end of the barn, the hay goes up to the opening near the top of the other end. The hay then slides along a track into the barn.

As you can see, fixed pulleys are very useful. But we also use pulleys in another way. An experiment will show you how we do this. Tie one end of a strong cord to a hook or nail high up on the wall. Then attach any small weight to the screw eye in the pulley frame. Put the cord through the pulley and then pull up on the other end of the cord. As you pull up, the pulley moves up, carrying the weight up with it. A pulley used in this way is called a *movable pulley* because it moves along the cord.

If you do another experiment, you can discover how a movable pulley helps make our work easier. Fill a pail or basket with sand, stones, or anything heavy. Use a spring balance to find out how much it weighs. How much force does it take to lift the weight? Now fasten the weight to the screw eye in the pulley frame. Tie the hook of the spring balance to the free end of the cord. Take hold of the ring of the spring balance and pull up until you lift the weight.

Look at the spring balance and see how many pounds of force you must use to lift the weight. How much force did it take to lift the weight without the pulley? Did it take more force or less force to lift the weight with the pulley? How does a movable pulley make your work easier? The hook or nail to which the cord is tied holds up half the weight. So you need to lift only the other half. Actually, you must lift a little more than half for a reason you will learn later.



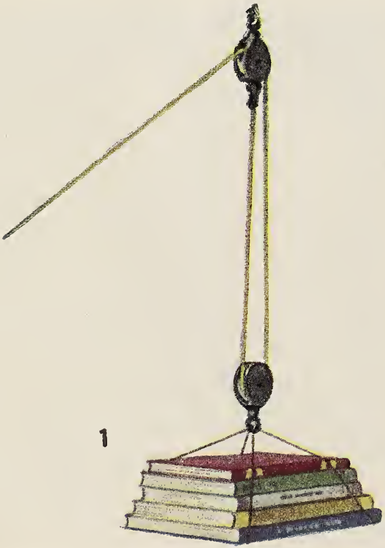


With a movable pulley, you can lift a heavy weight with a much smaller force. If you lift a weight of ten pounds with a fixed pulley, you have to pull with a force of about ten pounds. But if you lift a weight of ten pounds with a movable pulley, you have to use a force of only about five pounds.

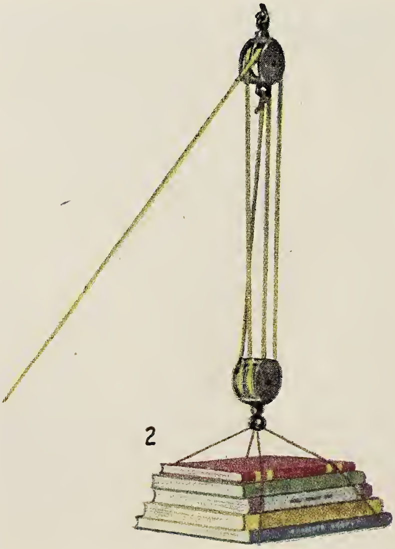
Often several pulley wheels are set side by side in one frame of wood or metal. The frame and the pulley wheels are called a *pulley block*. Two pulley blocks and the rope that runs over their wheels are called a *block and tackle*. The pictures on this page show how a block and tackle is used. The more pulley wheels there are in the block, the easier it is to lift a weight.

You can see that this is true if you do an experiment. Use one fixed pulley and one movable pulley to lift a weight, as shown in the first picture. With the spring balance, measure the amount of force you need to lift the weight. Then use a fixed pulley block with two pulley wheels and a movable pulley block with two pulley wheels, as shown in the second picture. With the spring balance, measure the force you need to lift the weight this time. Was it much easier to lift the weight when you used more pulley wheels?

Pulley blocks are used in cranes and derricks to lift heavy loads, such as big pieces of steel. They are also used to raise and lower elevators in tall buildings or lifeboats on ships. Pianos and safes are lifted to the upper stories



1



2

The painters pull their platform up to the top of the building with pulley blocks. How are the men in the other picture able to lift the heavy lifeboat?

of buildings with pulley blocks. Look at the pulleys in the pictures on this page.

Now let us see what we have learned about pulleys. They make our work easier in two different ways. With a fixed pulley, we can change the direction of a force. By pulling down on a rope, we can lift things up above our heads or to places where it is hard to go. It takes just as much force as it would without the pulley, but we can use the weight of our bodies to help us pull down. With a movable pulley or several pulleys together, we can lift heavy weights with much less force than we could if we did not use the pulleys.

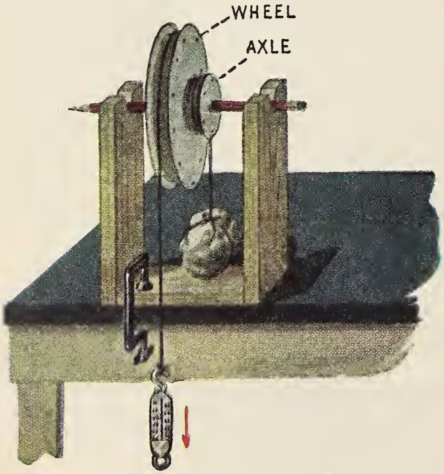
---

1. *In what two ways do pulleys make our work easier?*
2. *Tell how you could use a pulley to lift fifty pounds with a force of only about twenty-five pounds.*
3. *If a weight is very, very heavy, would you use one pulley or several pulleys to lift it? Why?*
4. *Tell what you have learned about each of these.*
   Fixed pulley   Movable pulley   Pulley block   Block and tackle
5. *Make a list of all the uses of pulleys that you can find.*

How do we use a wheel and axle?

A WHEEL is used in another kind of simple machine. This kind is called a *wheel and axle*. The rod that goes through the center of a wheel is the axle. The wheel of a pulley turns freely on an axle. But in a wheel-and-axle machine, the wheel is fastened firmly on the axle. When either the wheel or the axle is turned, the other one turns, too.

You can build a wheel-and-axle machine. Get a wide board at least one inch thick. Draw a circle six inches across on the board. Cut out the circle with a saw. Then draw a circle two inches across on the board and cut it out. In the center of each circle, bore a hole just big enough to force a round pencil through. The large circle will be the wheel, and the small circle will be the axle.



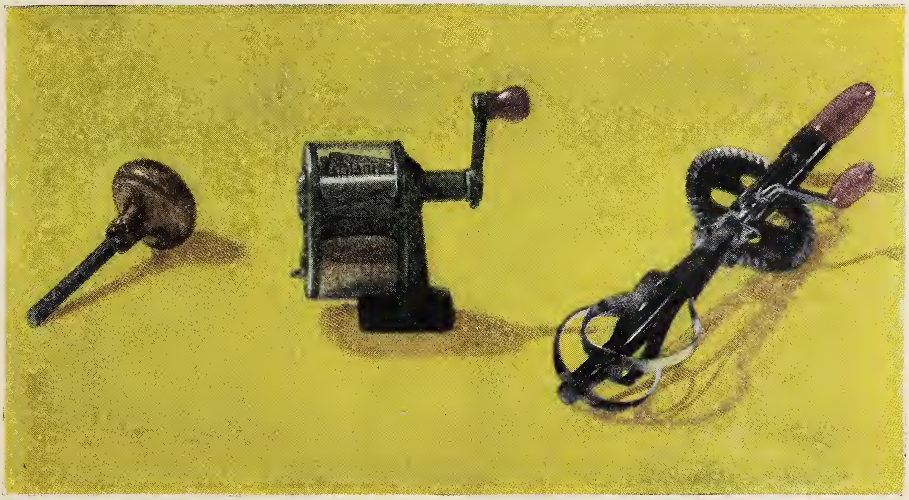
Cut two large circles and one small circle from cardboard. These should be just a little bigger than the wooden circles. Tack the cardboard circles to the wooden circles, as shown in the picture. Punch a hole in the center of each cardboard circle so that you can put a round pencil through it.

Now put the axle on the wheel so that the holes fit right together. Nail the axle to the wheel. Force the pencil through the holes. If it does not fit tightly, use glue to fasten it. Put a tack in the rim of each wooden circle. Tie a cord to each tack.

Make a frame from three pieces of wood, as shown in the picture. Nail the pieces together. Cut a notch in the top of each upright piece. Set the pencil in the notches. Clamp or hold the frame on the edge of a table.

Get a stone or any weight and weigh it. Wind the cord around the axle several times. Tie the weight to the end of this cord. Now wind the other cord around the wheel several times. Attach a spring balance to this cord. Pull down on the spring balance until the wheel turns and lifts the weight. How much does the weight weigh? How much force lifts it? What does this show?

You can find a wheel-and-axle machine in your schoolroom. Do you know what it is? It is a doorknob! Perhaps you never thought of the

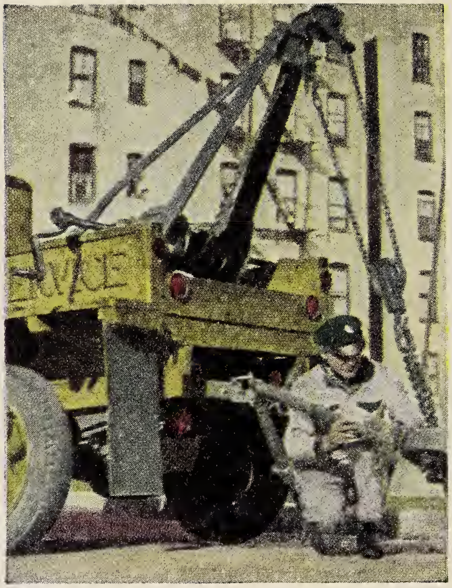


knob as a wheel. It does not have spokes as some wheels do, but it is a wheel just the same. The knob is fastened firmly to a rod that runs through its center. This rod is the axle. When the knob is turned, the rod also turns and moves a catch inside the door.

Let us see how this wheel-and-axle machine makes our work easier. Use a screwdriver to loosen the little screw that holds the knob on the rod. Take the screw out and remove the knob. Now try to turn the rod with your fingers. Can you make the catch move? Then put the knob back on the rod. Turn the knob with your hand. Is it easier to make the catch move now?

A wheel and axle helps us do our work. We can use it to increase a force. A little force on the knob produces a larger force on the rod. A wheel and axle acts like the lever you used in an experiment. You remember that a small force on the long end of the lever moved a heavy weight on the short end. The steering wheel of an automobile or bus is a wheel and axle. You know that you could not steer an automobile just by turning the rod to which the wheel is fastened.

If you look around your schoolroom again, you can probably find another wheel-and-axle machine. Is the pencil sharpener turned by a crank? The crank is really a spoke on a wheel. Instead of turning the whole wheel, you just turn one spoke. The crank turns the axle, and the axle moves the blades inside the



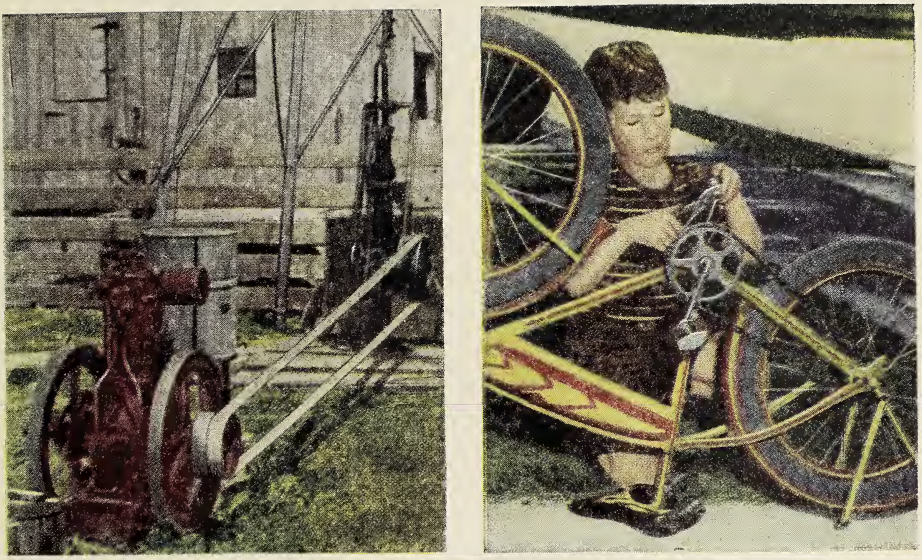
pencil sharpener. The crank of an egg beater, a meat grinder, or a clothes wringer is really a spoke on a wheel, too.

Without the crank, you would have a hard time making a pencil sharpener, an egg beater, or a clothes wringer turn. When a big wheel or a long spoke is fastened to a small axle, a little force on the wheel or the spoke will move a heavy weight attached to the axle. That is one reason why we use a wheel and axle in so many ways.

The picture on the right at the top of this page shows another wheel-and-axle machine. You may have seen a machine like this on the back of an automobile repair truck. Can you find the part that is the wheel and the part that is the axle? How does the machine help lift a heavy automobile?

---

1. *A pulley has both a wheel and an axle. Why is it not called a wheel-and-axle machine?*
2. *When you use a wheel-and-axle machine to increase your force, should you use your force on the wheel or the axle?*
3. *Why is a doorknob a wheel-and-axle machine?*
4. *Why is a large wheel used on the steering rod of an automobile?*



Can you find other machines in which a belt makes one wheel turn another?

How can one wheel turn another wheel?

WHILE PEOPLE were learning how to use wheel-and-axle machines, they discovered that they could also make one wheel turn another wheel. One way to do this is to put a tight band around the wheels. This band is called a *belt*. When one wheel is turned, the belt moves with it and turns the other wheel.

The chain on a bicycle is really a belt. Look at a bicycle and see how you make it go. You push down on pedals with your feet. The pedals are attached to the cranks that are fastened to an axle. The axle turns a big wheel, and this wheel moves a chain. The chain makes a little wheel turn, and this little wheel makes the rear wheel of the bicycle go around.

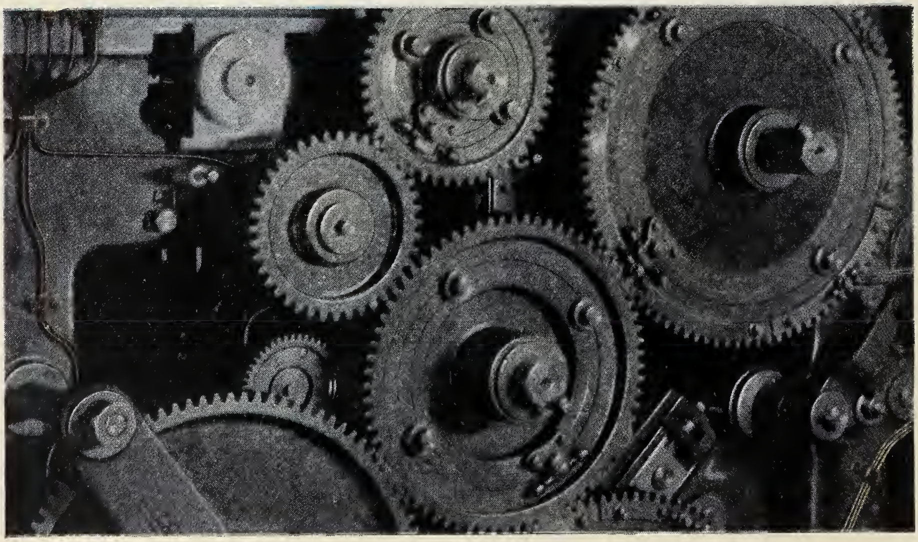
Notice that the wheels connected by the chain have notches and points on them. Crosspieces in the chain fit into the notches, and the points fit into open places in the chain. A wheel with notches and points on it is called a *gearwheel,* or just a *gear.* The points on a gearwheel are called *teeth.* The teeth and notches on a gearwheel help prevent slipping.

As people worked with wheel-and-axle machines, they found that they did not have to use a belt or chain to make one wheel turn another. They just put the rim of one wheel against the rim of another wheel. When one wheel is turned, it rubs against the other wheel and makes that one turn, too. But even when the wheels are pushed tightly together, they still slip a little. Do you know how we keep them from slipping? We use gearwheels instead of wheels with smooth rims. The teeth of one gearwheel fit into the notches of the other.

Look at the gearwheels in an egg beater. Notice how the teeth of the big wheel fit between the teeth of the smaller wheels. Turn the handle so that the big wheel goes around once. How many times do the little wheels go around? Do you see how we can use gearwheels to change speed? A big gearwheel turning slowly can make a little one turn much faster.

1. *When a large wheel turns a small wheel, does the small wheel go faster or slower than the large wheel? Give an example.*
2. *When a small wheel turns a large wheel, does the large wheel go slower or faster than the small wheel? Give an example.*
3. *What are two ways of making one wheel turn another wheel?*
4. *Tell how a special kind of wheel prevents slipping.*
5. *Use a bicycle to find out how many times the rear wheel goes around when the pedals go around once. Explain why this happens.*

Look at this picture carefully to see how one gearwheel turns another.



How can we make machines work better?

You know that it takes energy to produce a force that will make things move. Energy from food gives force to our muscles and the muscles of animals. The forces of moving air, moving water, and electric current come from the energy they have. Steam engines and gasoline engines get their forces from the energy stored in fuels.

Machines make our work easier because they help us make better use of the forces we have. We use machines to increase force, to change the direction of force, and also to change speed. But in every machine something moves. And when it moves, it rubs against something else. Moving parts rub against each other, or a moving part rubs against a part that stands still. When any two things rub against each other, we say that there is *friction* between them. Friction means rubbing.

In every machine you have used, there is always some friction. A lever rubs on its fulcrum. Things rub against the surfaces of inclined planes. A pulley wheel rubs on its axle, and a rope rubs on the pulley wheel. Wheels rub against belts, chains, and other wheels.

Some of the force that is used in a machine is always wasted. It is used to overcome the friction. To make up for this loss of force, we have to use more energy. So friction in machines wastes some of the energy that we use to do our work.

When you use a fixed pulley to lift a weight of ten pounds, you have to pull down with a little more than ten pounds of force. If you use one movable pulley to lift the same weight, you have to pull up with a little more than five pounds of force. With each pulley, you have to use a little more force than you would use if there were no friction. The extra force is used to overcome friction.

To make our machines work better, we try to keep friction as small as we can. There are several ways to do this, and we use them all. You can see one way that we use if you do a very easy experiment. Move a rough board over a rough board. Then move a smooth board over a smooth one. Did you have to use more force with the rough boards than with the smooth ones?

When rough surfaces rub on each other, there is much friction. But when smooth surfaces rub on each other, there is less friction. Wax on a floor or ice on a sidewalk makes such a smooth surface that you can slide easily. To make the parts of machines slide over each other easily, we make their surfaces as smooth as we can. If you look at some machines, you will see that the parts are very smooth.

Another way to cut down friction in machines is to put oil or grease between surfaces that must slide over each other. The oil or grease makes a very smooth, thin layer between the surfaces and keeps them from rubbing against each other. Of course, there is some friction between the oil or grease and the surfaces. But it is much less than the friction between the surfaces would be.

You can see that this is true if you do an experiment. Rub two flat pieces of metal back and forth against each other. Now put some oil or grease between the pieces of metal. Then rub them back and forth again. Can you feel how much easier they slide over each other now? This is one reason for oiling and greasing machines.

Here is another reason for using oil and grease. You know that when things keep rubbing on each other long enough, they finally wear out. And the rougher they are, the faster they wear. Friction between the soles of your shoes and floors and sidewalks makes your shoes wear out. Friction not only makes our machines waste energy, but it also makes them wear out. They will last much longer if we keep a layer of oil or grease between the surfaces that must slide over each other.

Oil and grease do another important thing, too. Rub the palms of your hands over each other as fast as you can. Do they soon feel hot? Try rubbing a penny back and forth on your sleeve as fast as you can. It will get so hot that you will find it uncomfortable to hold. If parts of a machine rub on each other, they get very hot. But when oil or grease is put between them, they slide over each other more easily. There is less friction, and they do not get so hot.

Friction in our machines wastes energy by changing it to heat we do not want. The waste of energy is bad enough, but the heat may be even worse. Did you ever hear anyone say he had "burned out" his automobile? Something kept the oil from getting between the moving parts of the engine. These parts will bend, break,

Two men can move this boat by using rollers. Look closely at the roller-skate wheel, and you will see the tiny ball bearings around the center of the wheel.

or even melt if they get hot enough. When there is no oil to keep them from rubbing against each other, they soon become too hot. Then the engine is ruined.

If you want your bicycle and roller skates to work well, be sure to keep them oiled. Put oil or grease on the parts that must slide over each other. Probably your mother keeps an oil can in your home. She puts oil on the moving parts of her sewing machine, vacuum cleaner, washing machine, and other household machines.

There is still another way that we use to cut down friction in our machines. We use wheels or something like them. It is easier to roll things over a surface than to slide them. An experiment will show you that this is true.

Fill a small box with sand, stones, or anything heavy. Slide it along the top of a table by pulling or pushing. Now set the box on a toy wagon. Move the wagon by pulling or pushing it. Is the box easier to move when you use wheels? Get about a dozen round pencils and lay them on the table a few inches apart. Set the box on the pencils and roll it over them. Do you see how the pencils act like the rollers men sometimes use to move heavy weights? If you can, get some little round metal balls or shot. Put them on the table and move the box over them. Is it easy to do?

We use wheels, rollers, and balls in our machines to cut down friction. They make the parts roll over each other instead of sliding over each other. Rollers and balls are used to

make *bearings*. A bearing is any part of a machine on which another part turns or slides. We call it a bearing because the other part bears down on it, or presses against it. As you might expect, much of the friction in a machine takes place at the bearings.

You can find one kind of bearing in a pair of roller skates or the rear wheel of a bicycle. This kind is made of balls. So it is called a *ball bearing*. If you look carefully around the wheels, you can see the balls. Another kind of bearing is made of rollers. It is called a *roller bearing*. We use roller bearings in the wheels of railroad cars and in other big machines. Bearings are made as smooth as possible. Then oil or grease is put on them to keep them from rubbing against each other or on other parts.

Most of the time we are trying to cut down friction in our machines. But sometimes we need to use friction, too. Some machines or some of the parts of machines would not work without friction. If there were no friction, belts would not turn wheels. The belts would just slip around on the wheels, and the wheels would not be turned. Friction also keeps things from slipping on inclined planes. In winter when there is much ice and snow, an automobile often cannot drive up a hill until sand or ashes are put on the road. The sand or ashes make the surface of the road rough. Then there is friction between the automobile tires and the road.

Did you ever see a toy express wagon with a brake on it? The brake is a handle on the side of the wagon over one of the back wheels. When you want to stop or slow down, you press this handle against the wheel. Friction between the end of this handle and the wheel makes the wheel stop moving. The brakes of automobiles and trucks work because of friction. The brakes have a rough material on them that causes much friction when they press against a part of the wheel.

We need friction between the tires and the road, too. The tires are made so their surfaces are not smooth. This makes friction between the tires and the road. When the tires are old and worn, they become smooth. Then there is less friction. The automobile slides easily and does not stop quickly when the brakes are put on.

If you play baseball, you know that you cannot bat the ball very far if the bat slips around in your hands. If the handle of the bat is slippery, you can put some tape around the handle to make it easier to hold tight. You are making more friction between the bat and your hands.

Think of other machines you have read about or used. Can you think of some that work better because of friction?

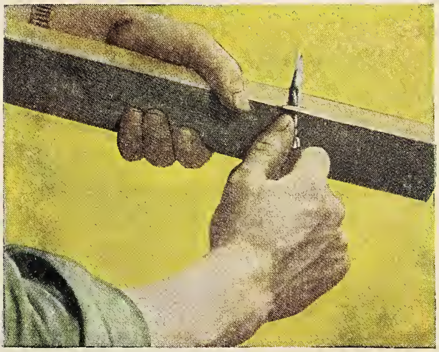
---

1. *Give three reasons why we try to cut down friction in our machines.*
2. *What different ways do we use to make our machines run better? Tell how each way helps.*
3. *Why do pianos and other heavy pieces of furniture often have small wheels called casters under them?*
4. *The axles of the wheels of railroad cars sometimes get very hot. What do you think causes this?*

How can we use machines safely?

THE OTHER DAY, a little girl got her hand caught in the wringer of her mother's washing machine. Her hand and wrist were badly hurt. Machines help us. But they are dangerous, too, unless we use them carefully. Every year, thousands of people are hurt by machines. Sometimes it is not the fault of the people. Many times, it is entirely their fault. They are just careless or in too much of a hurry.

Knives, saws, hammers, and axes are helpful machines that we often use. They can be dangerous, as you know. Axes and knives have very sharp edges. If an ax or a knife slips or suddenly breaks through the wood, you may get a bad cut. If you are cutting with a knife, cut away from yourself—not toward yourself.



In factories, belts and gears must all be covered so that the people who work near them will not be injured by them.

If you are hammering, give the nail a few light blows while you are holding it to get it started. Then move your hand away while you drive the nail in with heavy blows. The jagged teeth of a saw make a bad wound. You may have to hold your hand close to the saw to guide it when you start sawing. Be very careful when you do this.

Many times, fingers and hands have been badly cut or bruised by getting caught between a rope and a pulley. You can burn the skin on your hands if you hold too tightly to a rope that is sliding through pulleys rapidly.

Wheels with swiftly running belts have hurt and killed thousands of people. A piece of a person's clothing sometimes gets caught in the belt, and the person is thrown against a ceiling or wall with great force. It is important to be very careful if you are near wheels and belts. Stay safely away from them when they are running.

Gearwheels are very dangerous. Once you get your hand or arm caught between two moving gearwheels, you cannot get it out. Gearwheels are so dangerous that in many states the owners of factories are required by law to have all gears covered. If you live on a farm, there are plenty of dangerous gearwheels for you to be on guard against.

Sometimes on playgrounds boys and girls are careless and are injured by levers. A boy or girl will think it is funny to jump off the end of a seesaw when the child on the other end is high up in the air. When the high end comes down with a bang, a leg may be caught under it and severely hurt or even broken. Levers may be dangerous in other ways. If you are pushing down hard on a lever, the weight you are trying to lift may suddenly move up. Down you go. Your fingers may be bruised or broken. You may even get a bad bump on your head. The same things may happen if the lever breaks when you are pulling on it.

There are hundreds of ways in which machines can injure you. You must learn to be careful with machines. One big thing for you to remember when you are using machines is this. *Never hurry. When you hurry, you are likely to get careless.*

Safety rules for using machines

1. Have a place for each machine and put it back in its place when you are through using it.
2. Never leave tools on a stairway.
3. Have a place for brooms and mops where they cannot fall across a passageway.
4. Set heavy tools where they cannot fall on someone.
5. Put knives and other sharp tools away with the sharp edges pointing away from the person who will next pick them up.
6. Do not run with a pointed tool, such as a knife or a pair of scissors.
7. Always cut away from yourself when using a sharp tool.
8. Lay garden tools on the ground so that the sharp parts are pointing downward.
9. Be very careful when you use machines with wheels, belts, and gears, such as electric fans, sewing machines, washing machines, and clothes wringers.
10. Keep your fingers away from wheels and gears when they are moving.

---

1. *Tell some dangerous things you have seen people doing with machines.*
2. *Make a list of "danger spots" around machines in your home.*
3. *There should not be any "danger spots" around machines in your school. Find out whether there are such spots.*

QUESTIONS TO ANSWER

1. In the pictures on these two pages, people are using machines to help with their work. What kinds of machines are they using? How are these machines making the work easier?

2. What kinds of simple machines could you make from a board and a block of wood? What kinds could you make from a wheel and a rod?

3. How are fixed pulleys different from movable pulleys?

4. Which kind of simple machine is used to—split wood, pull nails, roll a heavy barrel onto a truck, make windows open and close easily?

5. How many different kinds of machines can you find in your school? Tell what each kind is used for.

6. What part of a wheel and axle needs to be greased or oiled? Why?

7. Tell one important thing you have learned about each of these—friction, simple machines, fulcrum, belts, gearwheels, ball bearings.

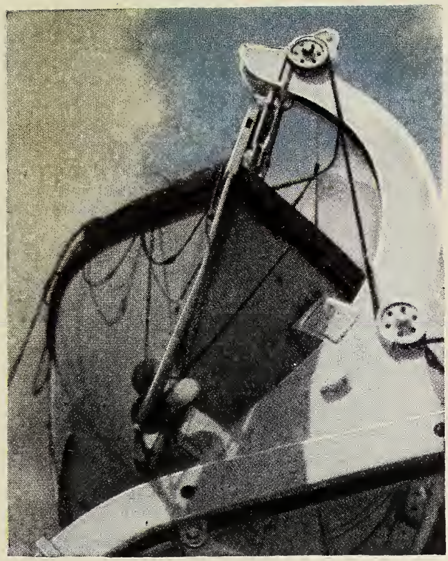
8. Sometimes we want to increase friction. Give some examples that show this.

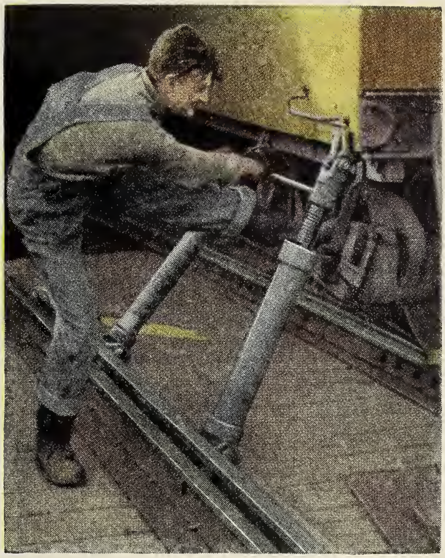
9. How do you think the world would be different if we had no machines?

THINGS TO DO

1. Look at some of the machines in your home and try to find out how they work.

2. Make a list of the machines you have seen being used while you were studying this unit.



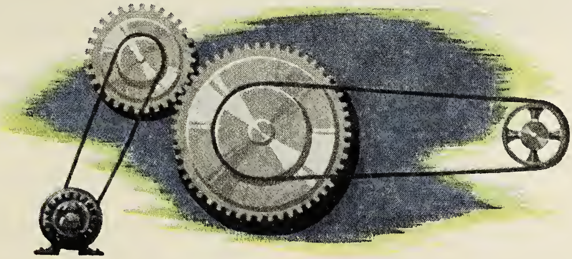


3. Find pictures that show how machines are used to do different kinds of work.

4. Ask someone in your class to bring his mechanical building set to school. Make some machines and find out how they work. Show what kinds of simple machines you use.

5. Make a collection of all the kinds of tools you can find that are simple machines. Show what kinds of simple machines they are and how they help you do work.

6. Bring some of your toys to school. See how many simple machines you can find in each toy.



★ In Unit Four You Will Learn ★

★ How heating and cooling change the size of solids ★
★ What happens when liquids are heated or cooled ★ How hot water heats a house ★
★ How heating and cooling change gases ★ How hot air heats a house ★
★ How solids are changed to liquids ★ How liquids are changed to gases ★
★ How water vapor is changed to liquid water ★

UNIT 4

How Do Heating and Cooling Change Materials?

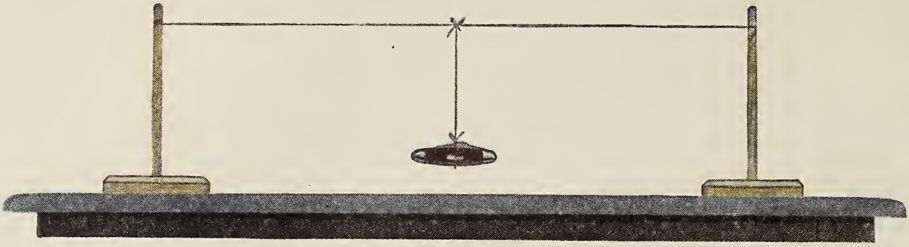
Jack's mother was getting supper. When she had almost finished, she asked Jack to get a jar of fruit from the basement. Then she asked him to open it. It was a glass jar with a metal top that screwed on. But Jack could not unscrew the top, no matter how hard he tried. When his mother saw the trouble he was having, she said, "Pour a little water into a pan and put the pan on the stove. Use just enough water to cover the metal top. Stand the jar upside down in the water until the water is hot. Then try to unscrew the top."

Jack did as his mother said. To his surprise, he was able to unscrew the top very easily. "Why did hot water make it easy to get the top off?" asked Jack.

How do heating and cooling change the size of solids?

Do you know why the top of the jar came off so easily when it was heated by hot water? Suppose you try an experiment to find out. Stretch a piece of copper or iron wire about three feet long between two supports on a table. Stretch the wire as tight as you can. Hang a small stone or weight from the center of the wire so that the weight almost touches the table. The picture on page 104 will help you be sure that your experiment is set up correctly. Heat the wire along its entire length. The experiment will not work unless the whole wire is well heated. What happened to the weight? What did heat do to the wire? Leave the weight on the wire because you will need to look at it again.

In the pictures on page 105, the girl is doing another experiment. This one shows what heat does to a solid metal ball. In one hand, the girl is holding a



rod with an iron ring in the end of it. In the other, she has a rod with an iron ball on the end of it. The ball will just go through the ring. In the middle picture, she is heating the ball. Does it go through the ring after it has been heated? When the ball gets very hot, it will not go through the ring. What do you think has happened to the ball?

Suppose that you had a bolt and a nut that just fits the bolt. And suppose you took the nut off the bolt and then heated the bolt in a very hot flame. Do you think the nut would still fit the bolt? It would not, because heat does something to the bolt. Heat would make the bolt so large that the nut would no longer fit on it.

Do you think you know now why the hot top of the jar unscrewed so easily? You may want to try another experiment to be sure you are right. Get a strip of metal and nail both ends down flat on a board. Then heat the metal strip and watch to see what happens. How do you know that the heat is making the metal strip longer?

You saw that the wire became longer when you heated it. It became bigger around, too, although you could not see that. The bolt and the ball will also get bigger if they are heated. We say that these things *expand* when they are heated. This is another way of saying that they get larger, or take up more room.

If you tried many different kinds of solids, you would find that almost all of them expand when they are heated. Now do you see why Jack could unscrew the hot top of the jar? The hot water made the metal top hot. The heat expanded the top faster than it did the glass of the jar. The top got larger. So it was not so tight on the jar. Then the top could be unscrewed easily.

When most solids are heated, they expand. What do you suppose happens when they are cooled? To answer this question, look at the wire you heated after it has become cool again. Does the weight still touch the table? Or is it in the same position it was before you heated it? The wire gets shorter when it is cooled. We say that the wire *contracts*. Contract means get smaller. When the heated bolt cools off, the nut will fit it again. Almost all solids contract, or get smaller, when they are cooled.

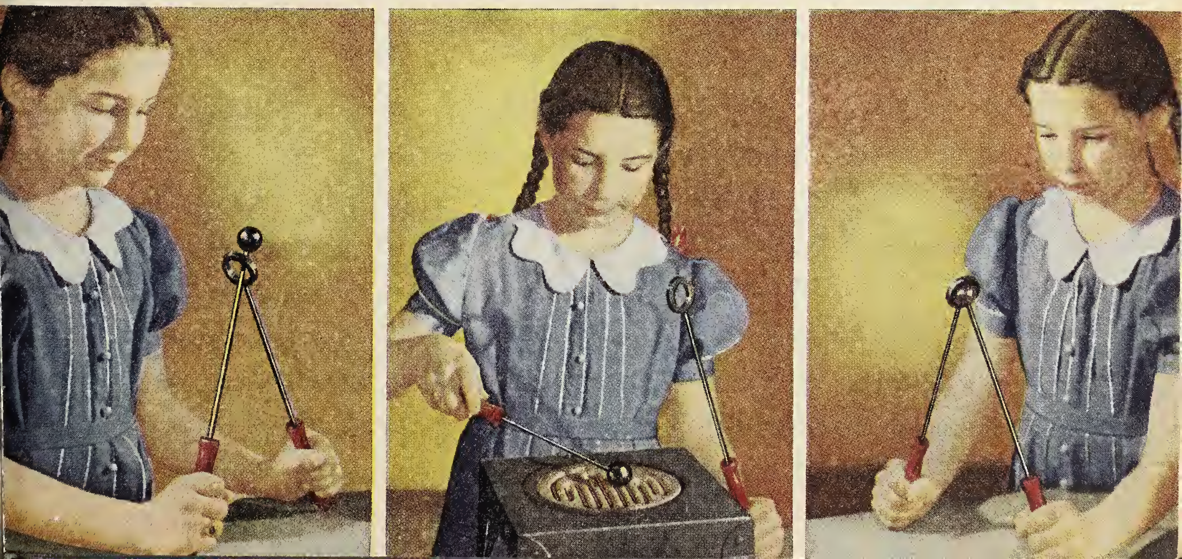
On a very hot summer day, Jack and his father were waiting to cross a long metal bridge. The bridge had opened to let a boat go past. While they were waiting, Jack's father said, "This bridge is several inches longer now than it was last winter when we crossed it."

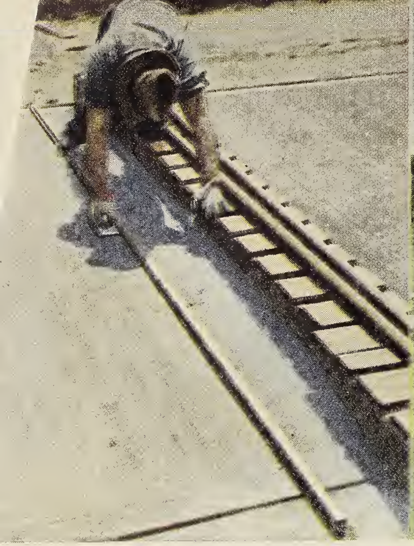
A little later, as they were driving along a country road, Jack's father said, "See those telephone wires sag. They are longer now than they were last winter." Did Jack's father really mean what he said? Or was he joking?

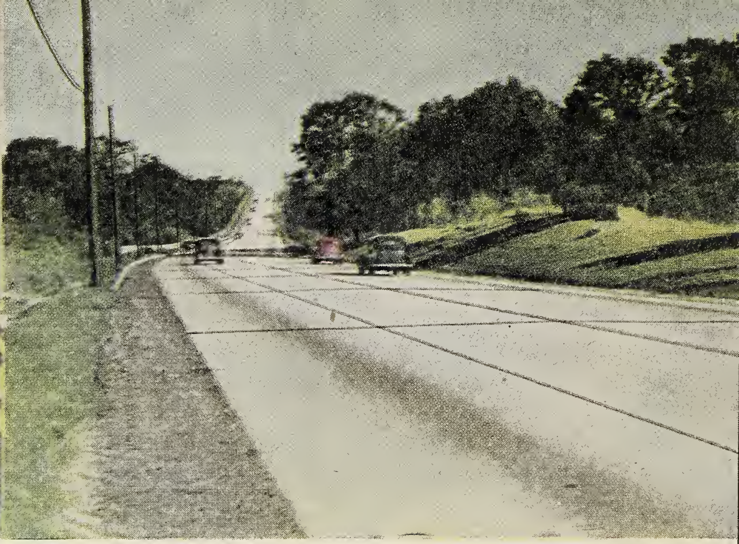
Men who build metal bridges know that the bridges will get longer when the hot summer days come. They build the bridges so that there will be room for them to expand. Sometimes one end of a bridge rests on rollers. When heat expands the metal in the bridge, the end of the bridge can move. Metal bridges are not always placed on rollers, but there is always room left for them to expand when they are heated by the sun. What do you think would happen if the bridge builders did not leave room for the bridges to expand?

Perhaps some of you live where there are huge bridges like the one on page 103. Bridges like this are held up by long, thick ropes, or cables, made of wire. On hot days, the cables are longer than they are on cold days. So the bridge goes up and down a little as the weather changes. But it moves so slowly that you cannot feel it.

Have you ever ridden along a concrete road in summer and felt your car go bump, bump, bump? Do you know why you felt those bumps? Concrete roads are not made in one long strip that goes on for miles. Instead, they are usually made in short







blocks. Between these blocks the road builders leave a small space.

The picture on the left at the top of this page shows how a space is made between the strips. A piece of board is put down into the roadway before the concrete is poured. When the concrete is poured, it comes only up to the board on each side. The concrete hardens. Then the board is taken out, and there is a space between the two strips of road. Often this space between blocks is filled with tar.

Of course, you know that heat makes the tar expand. It also makes the concrete expand and squeeze the tar. So the tar bulges up through the space. When the wheels of the car travel along the road over these bulges of tar, you feel the bumps. You can see the black lines of tar in the picture on the right.

---

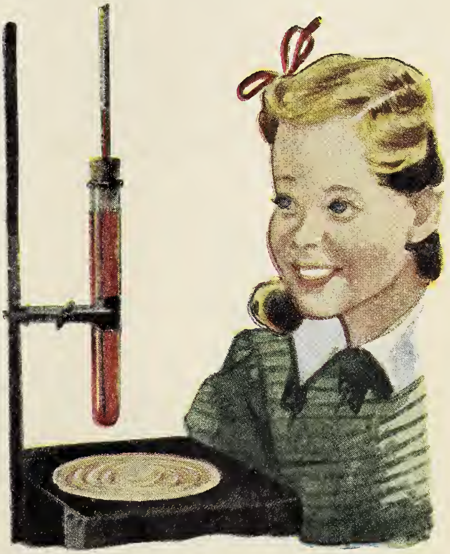
1. *Why is it important for people to know that heating and cooling change the size of solids?*
2. *What does* contract *mean? What does* expand *mean?*
3. *Windows that open onto fire escapes usually are made with metal frames. Will the windows fit as tightly in winter as in summer? Explain your answer.*
4. *Suppose some workers were stringing telephone wires between poles on a very hot day. Should they stretch the wires tightly? Or should they let the wires sag? Explain your answer.*
5. *What might happen to a concrete road if the builders did not leave a space between the blocks of concrete? Why?*

What happens to liquids when they are heated or cooled?

When John was studying science, he was always thinking of experiments to do at home. One time he decided to find the answer to this question. How hot does water get when it boils? He found a thermometer that his mother said he could have, and he put a pan of water on the stove. While the water was still cool, he set the thermometer in it. As the water slowly heated, the red liquid in the thermometer went up and up. At last, it reached the top of the thermometer. Suddenly the glass broke, and the red liquid ran out into the water.

What made the thermometer burst? Here is an experiment that will help you to find out. You will need a test tube and a rubber or cork stopper with a hole in it. Use a stopper that just fits into the test tube. Get a piece of glass tubing about a foot long that will fit into the hole in the stopper, as shown in the picture.

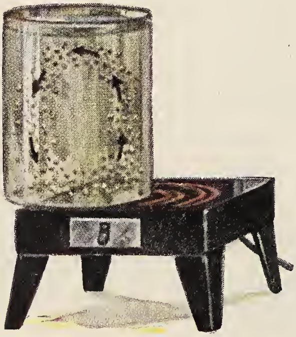
Fill the test tube with water. Use red ink to color the water so that you can see it easily. Fit the glass tubing into the stopper and then put the stopper into the test tube. Push the stopper down tight so that some of the water rises in the tubing. Mark the level of the water on the side of the test tube. Now heat the water slowly and watch carefully to see what happens. Mark the level of the



water after it is heated. Is this mark above or below the mark that showed where the water was when it was cool? Did the water expand or contract when it was heated?

You see that when the water is heated, it expands just as most solids do. As the water expands in the test tube, it goes up into the glass tubing. Now cool the test tube and watch the water. Why does it go down in the glass tubing? When the water is cooled, it contracts. Most liquids expand when they are heated and contract when they are cooled.

You know now why John's thermometer broke. The liquid in the thermometer got very hot. It expanded until it took up all the room in the glass. Then it kept expanding until it pushed so hard that it broke the glass and ran out. Some thermometers are made so that they will not break in boiling water. The thermometer is long enough so that there is plenty of room for the liquid to expand. But John did not have that kind of thermometer.



Hold your finger on the bulb of the thermometer in your schoolroom for a minute or two. Why does the liquid rise in the tube?

If you fill a teakettle to the top with cold water and then heat the water, what will happen? Why does this happen? Can you use what you have learned to explain what happened when Jack's mother canned some tomato juice? She boiled the juice and filled glass jars full of the hot juice. Then she sealed the jars and put them away in the cool basement. She opened one of the jars a few weeks later and found that it was no longer full to the top. Do you know why?

You have learned that heat makes most liquids expand. When liquids expand, something else happens to them. Here is an experiment that will help you to understand what it is.

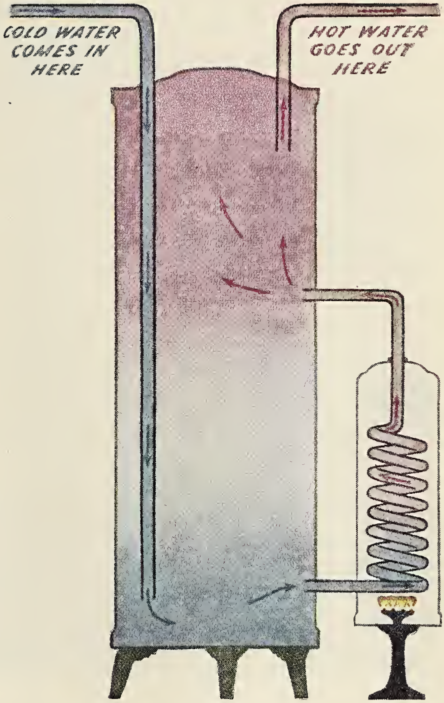
Fill a large glass jar with water and put a teaspoonful of coarse sawdust in the water. The sawdust will soon get soaked with water and sink to the bottom. Now heat only one side of the bottom of the jar and watch the sawdust. Why does the sawdust move up from the bottom of the jar on one side and then down on the other side and then up again?

Water carries the sawdust. The water at one side of the bottom of the jar is getting hot. You know that it is expanding. It is also getting lighter.

It gets lighter in weight because it expands. You know that a teakettle brimful of cold water will run over when it gets hot. The water in the teakettle weighs less when it is hot than when it was cold. A gallon of cold water actually weighs more than a gallon of hot water.

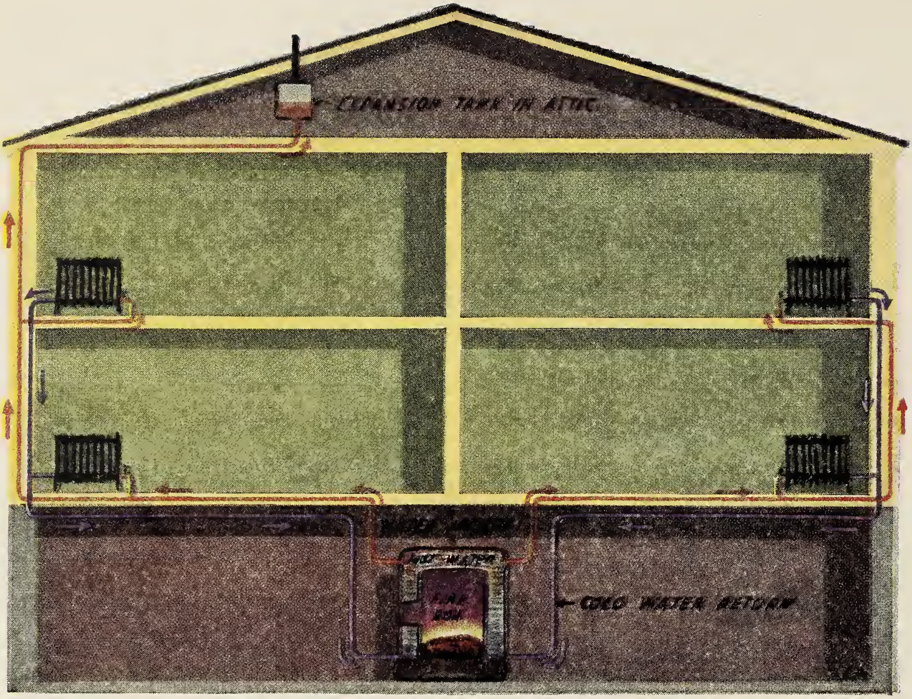
In the experiment, the water on the side of the glass jar that is not heated is cooler than the water on the heated side. It is also heavier than the warmer water. Gravity pulls down harder on the heavier, cooler water. It sinks to the bottom along one side and pushes the lighter, warm water up. This makes a current in the water. Look at the arrows in the picture on page 108 and trace the current. The arrows show that the heavier, cold water is sinking and pushing the lighter, warm water up.

Look at the hot-water heater in the picture on this page. You will see that it works much like the experiment with the sawdust. As the water is heated in the small tank, the cold water that comes in at the bottom pushes the warm water up and into the top of the big tank. Follow the red and blue arrows, and you will see how the current moves.



---

1. *Why does the colored liquid in a thermometer go up and down as the temperature changes?*
2. *Why is there a current in a jar of water when it is heated on one side?*
3. *If the radiator of an automobile is filled clear to the top, what do you think will happen when the engine gets hot? Why?*
4. *When you put a kettle of water on the stove to heat, should you fill the kettle full? Explain your answer.*



How is hot water used to heat a house?

You now know two things that heat does to water. So you can understand how hot water is used to heat a house. Study the picture of a hot-water furnace on this page. Notice the firebox in which the fuel is burned. There are two walls of iron around the firebox. There is water between these walls. This space filled with water is called a *water jacket.*

Pipes run from the top of the water jacket up through the house. Other pipes run into the lower part of the water jacket. The pipes connect the furnace with the radiators that are in the rooms of the house. Look at the picture again. Find the pipes that run from the furnace to the radiators. Do you see the pipe that runs from each radiator back down to the furnace?

When there is a fire in the furnace, the water in the water jacket gets hot. The water expands and gets lighter. Upstairs the water in the radiators and pipes is cool. This heavy, cool water begins to sink down through the pipes marked with the blue arrows into the lower part of the water jacket. It pushes the lighter, hot water up through the pipes marked with the red arrows and into the radiators.

The heat from this water in the radiators goes into the rooms and makes them warm. As the water in the radiators gets cool, it contracts and gets heavier. It goes back down to the furnace where it is heated again. The water travels just as it did in the experiment with the sawdust in the jar of water.

If your home is heated by hot water, find out where the pipes are that carry the hot water up to the rooms. Find the place where the pipes carry the cool water back into the furnace. See how the pipes go to each radiator. Look carefully at your furnace and try to find out how it works.

---

1. *Why does water move through the pipes in a house heated by hot water?*
2. *Trace the current of water in the furnace on page 110 and explain how the upstairs rooms are heated.*
3. *In some houses, like the one on page 110, the hot-water pipes are connected to a tank in the attic. Why is this done?*
4. *Are the hot-water pipes connected to the top or to the bottom of the water jacket? Are the cold-water pipes connected to the top or the bottom of the water jacket? Why are they connected in this way?*

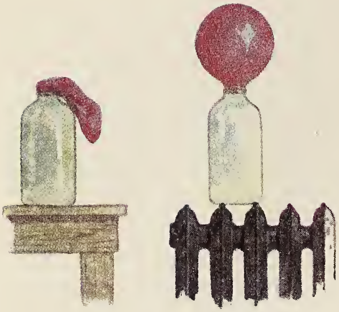
How do heating and cooling change gases?

YOU HAVE LEARNED that heat makes solids and liquids expand and that cooling makes them contract. Do you think that heating will make a gas expand and that cooling will make it contract? Suppose you try a few experiments to find out.

For your first experiment, stretch the neck of a toy rubber balloon over the mouth of a bottle. Heat the bottle in a pan of hot water or on a hot radiator. Watch the balloon. Why does it begin to swell?

You know that you must blow air into a toy balloon to make it swell. You know that some air went into the balloon in the experiment you just did. But where did the air come from? Of course, you know that there was air in the bottle. When you heated the bottle, you heated the air inside it. Some of this warm air went out of the bottle into the balloon. This shows that when air is heated it expands. So some of the heated air is pushed out into the balloon.

Leave the toy balloon on the bottle and put it outdoors or in some cold place. Watch what happens to the balloon this time. What happens



when the air in the bottle is cooled? When air is cooled, it contracts. The shrinking balloon shows how much less room the cold air takes up.

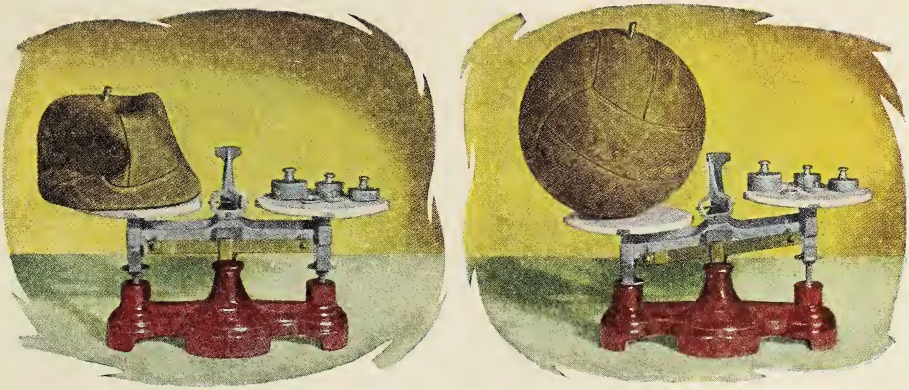
Try another experiment to make sure that air expands when it is heated. Find a bottle with a small neck. Put it outdoors or on some ice where it will get cold. Then fill a glass with water. When the bottle is cold, put its mouth straight down into the water in the glass. Hold both your hands tightly around the bottle so that the heat from them will warm the bottle and the air inside the bottle.

Do you see anything come out of the bottle? If nothing happens, you are not making the air warm enough. Be sure to keep the mouth of the bottle under the water.

You can probably explain why the bubbles came out of the bottle. When the air in the bottle was warmed, it expanded. It pushed out into the water and bubbled to the top. The bubbles were air. Again you have found that air expands when it is heated.

Use the same bottle and glass of water and do the experiment in just the opposite way. Get the bottle very warm by putting it in hot water. Then quickly put the mouth of the bottle straight down into the glass of water. Be sure to keep the mouth of the bottle under the water all the time. Take some ice and hold it around or on top of the bottle to cool the air inside the bottle. What happens? Can you tell why the water goes up into the bottle?

When the air inside the bottle is cooled, it does not take up so much room as it does when it is warm. The air outside the bottle pushes the water into the bottle to fill the place left by the air as it contracts. This happens because air contracts when it is cooled.



Does this picture show that air really weighs something?

Air expands when it is heated. It contracts when it is cooled. Of course, you remember that air is not a solid or a liquid. Air is a mixture of gases. All gases expand when they are heated. And all gases contract when they are cooled.

Now do another experiment to discover another important thing about air. When you discover this, you can explain many things about heating your home. Get a basketball or a volleyball and a pair of scales. Also get a bicycle pump. Let all the air out of the ball and weigh the ball. Now take the ball off the scales and pump air into it until it is quite hard. Put it back on the scales. Is it heavier? Does air really weigh something?

Probably you have never thought that air has weight. But when you filled the ball with air, it was heavier than it was when it was empty. All materials have weight, and air is a material.

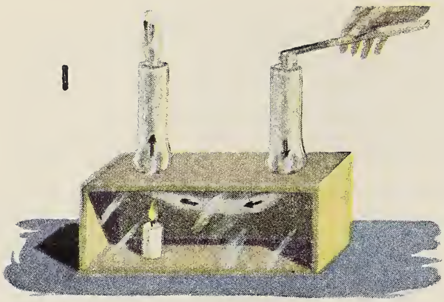
If you could fill the ball first with cold air and then later fill it with hot air, you would find that the cold air weighs more than the hot air. Cold air is heavier than the same amount of hot air. Gravity pulls down with more force on the heavier, cold air.

You have now learned three important things about air.

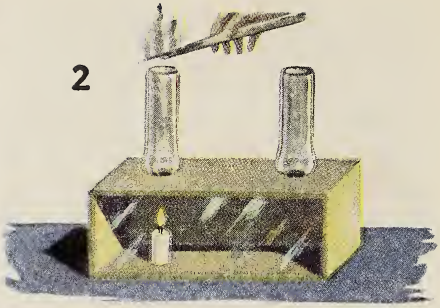
1. Air expands when it is heated and contracts when it is cooled.
2. Air has weight.
3. Cold air is heavier than the same amount of hot air.

Knowing these things will help you explain why air acts the way it does. For your next experiment get a wooden box like the one in the picture on page 114. A box about twice as large as a chalk box will work well. You will also need two lamp chimneys and

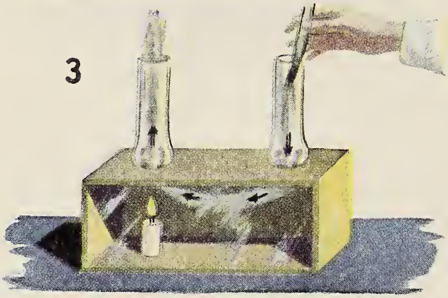
1



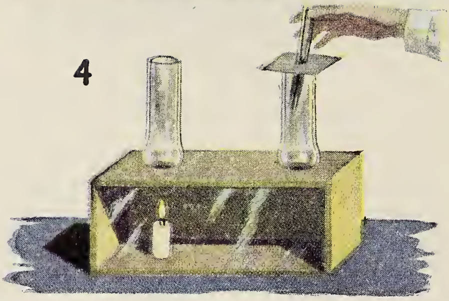
2



3



4



a piece of glass. Use cardboard tubes if you cannot get lamp chimneys.

Cut two holes in the top of the box and place a lamp chimney over each hole, as you see in the picture. Put a small candle in the box under one of the chimneys. Light the candle and cover the open side of the box with a piece of glass. Now light a splinter of wood or a roll of paper. Let it burn a moment and then blow out the flame.

With the splinter still smoking, hold it over the lamp chimney that has no candle under it (Picture 1). Where does the smoke go? Now hold the smoking splinter over the other chimney (Picture 2). Where does the smoke go? What does the smoke show you? If you see the smoke moving, you know which way the air is moving because the smoke is being carried by moving air.

Light the splinter again and blow it out. This time place the smoking splinter farther down inside the chimney that has no candle under it (Picture 3). What happens to the smoke in the box?

Now put a splinter through a piece of cardboard big enough to cover the chimney. Make the splinter smoke and put it down in the chimney that has no candle under it (Picture 4). Hold the cardboard tightly against the top of the chimney. What happens to the smoke now? Why has it stopped moving?

If you answer these questions, you will understand what has happened.

How did the heat from the candle change the air around the candle?

Which way did the air move in the warm-air chimney?

Which way did it move in the cool-air chimney?

The warm air went up, and the cold air came down. Can you tell why the cold air came down? This is the reason. When air is heated, it expands. So there is not so much air in the same amount of space as there was before the air was heated. Cool air is heavier than the same amount of warm air. Gravity pulls down harder on the heavier, cool air than it does on the warm air.

The air in the cool chimney is heavier than the air in the warm chimney. So the cool air sinks down into the box and pushes the lighter, warm air up out of the warm chimney.

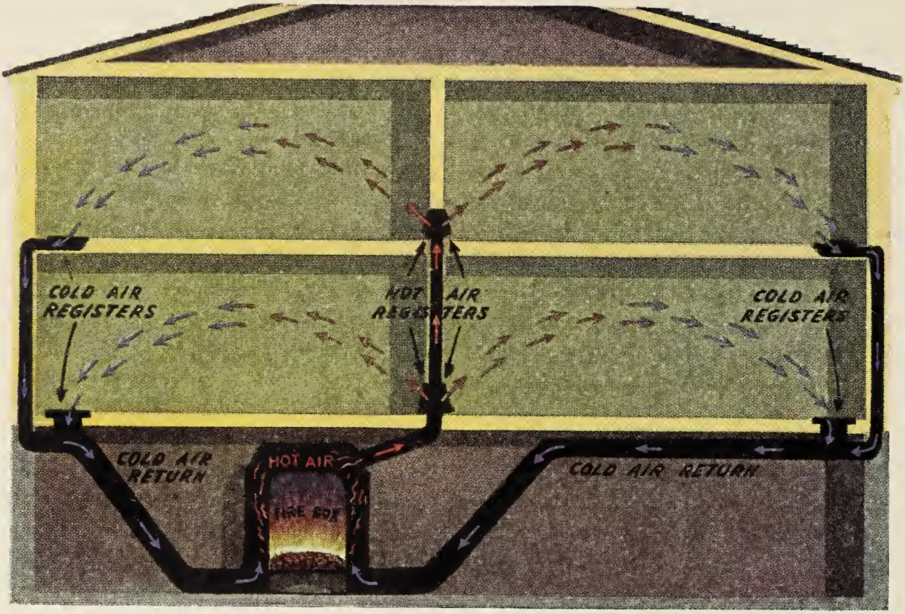
When you covered the chimney with cardboard, the smoke did not move. So you can be sure that the air was not moving. The cardboard cut off the air from above the chimney and kept the heavier, cool air from moving down into the box. The smoke did not move. So you can be sure that the air did not move.

---

1. *One hot summer day, John and his father were riding in their car. Suddenly there was a loud bang. One of the tires on the car had blown out.*

   "I told the garage man not to put too much air in that tire," said John's father. "It's an old tire."

   Why was it not safe to put so much air in that old tire on a hot day?
2. *Each sentence below has a blank in it. Choose a word to take the place of the blank so that the sentence will tell something true about what heating or cooling does to gases.*
   - *a) Gases__________when they are heated.*
   - *b) Gases__________when they are cooled.*
   - *c) Cool air is__________than the same amount of warm air.*
3. *If a football is pumped up in a warm room and then taken outdoors on a cold day, will it get harder or softer? Why?*
4. *You have learned what heating and cooling do to solids, liquids, and gases. What two things happen to all of them?*



How does a hot-air furnace heat a house?

THE BATES FAMILY was getting ready to move into a new house. One afternoon, Betty's father said, "Let's go over and see our new house. I have just built a fire in the furnace."

By the time they got to the house, Betty was cold. As soon as they were inside, she went over to a grating at one side of the room. "I thought there was a fire in the furnace," she said. "There isn't any heat coming up through here."

"Of course not," replied her father. "That is a cold-air *register*. Over here is the place where the hot air comes up from the furnace."

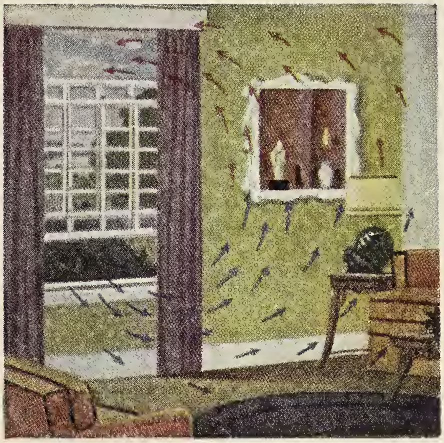
After a while, they all went down to look at the basement. Here Betty's father showed her the big pipe that brought cold air into the bottom of the furnace. She also saw the pipes that carried hot air up into the rooms.

Your experiments have helped you understand how the hot air and the cold air moved in Betty's house. The cold air was heavy. So it sank down the pipes to the bottom of the furnace and pushed up the air that had been heated. This hot air went up the pipes to the rooms. It came out of the hot-air registers and rose to the ceiling. Then it began to get cooler and heavier. It sank down through the cold-air registers into the pipe and then to the bottom of the furnace. In this way, the air was kept moving through the house and through the hot-air furnace.

Look at the picture on page 116 and see how the air moves. Are the arrows placed correctly to show how the air moves? What makes the air move up to the rooms? What makes it come back to the furnace?

Do an experiment to find out whether the air near the ceiling is warmer. Get two thermometers. Hang one up near the ceiling and place the other near the floor. In a few minutes, read both thermometers.

What you have just learned about hot and cold air will help you *ventilate* your bedroom. As you probably know, ventilate means change the air. This experiment will show you how to do it. Open one of the windows in your schoolroom at both the top and the bottom. Fasten several strips of paper to the top of a window pole. Then hold the pole so that the strips of paper are at the top opening of the window. Also hold some other strips of paper at the lower opening.



Watch the strips of paper to see which way they are moved by the air. How can you tell at which opening fresh air comes into the room? The fresh, cool air comes into the room at the lower opening and pushes the lighter, warm air to the top of the room and out at the top opening of the window.

You have learned how important fresh air is in keeping you healthy. A well-ventilated room is a much more healthful place than one that is not well-ventilated. At night, if you open your bedroom window at the top and also at the bottom, your room will have plenty of fresh air.

---

1. *How does a hot-air furnace heat a house?*
2. *Trace the moving air in the picture on page 116 and tell how the rooms are heated.*
3. *How would you open the windows to ventilate a room? Explain why you would do it in this way.*

Which of these will melt first—the paraffin, the lead, or the ice?

How are solids changed to liquids?

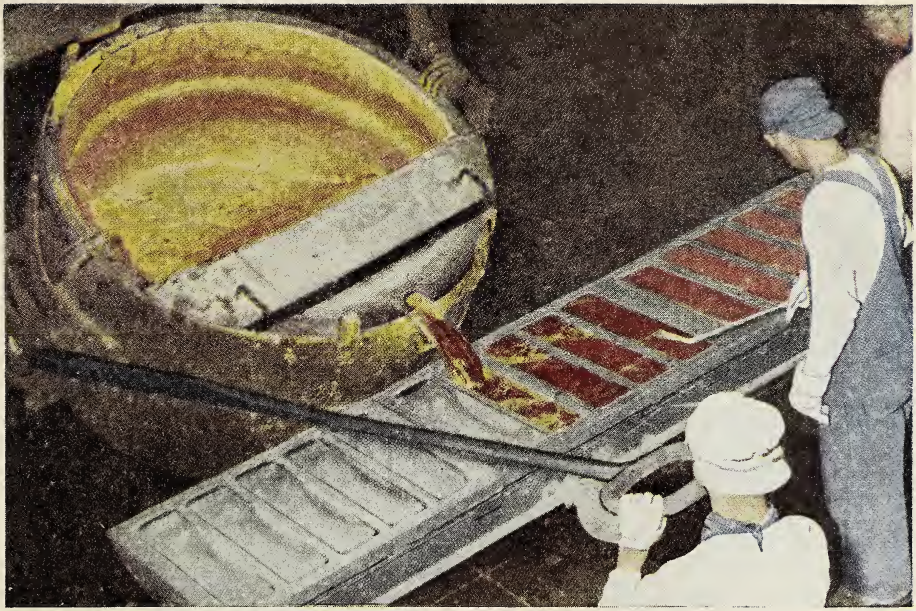
SUPPOSE YOU TRY this experiment. Take an iron pan and put in it a piece of hard butter, a piece of paraffin, a piece of lead, and a piece of aluminum. Put the pan over a hot fire. Which materials melt first? The butter and the paraffin melt first. Pour them out as soon as they have melted. The lead melts next. Did the aluminum melt? You could not get the pan hot enough to melt the aluminum or the iron of the pan. But you probably know that fires can be made so hot that they will melt iron and aluminum.

Many solids change to liquids when they get hot, but different kinds of solids melt at different temperatures. The temperature at which a solid melts or changes to a liquid is called the *melting point* of that solid.

Do you know what the melting point of ice is? You can find out if you try this experiment. Put a thermometer into a pan of melting ice. Look at the thermometer several times as the ice melts. If you were careful, you found that the melting point of ice is 32° F. (F. stands for *Fahrenheit,* the kind of thermometer we usually use. The little circle after 32 means degrees.) When the temperature of ice gets to 32 degrees Fahrenheit, the ice changes to water.

Lead must be heated to 620° F. before it will change to a liquid. Aluminum must be heated to about 2000° F. before it will melt. The big furnaces where iron is melted go to a temperature of over 2700° F. before the iron in them will melt.

When the melted materials get cool enough, they change to solids again. So we can melt solids and *mold* them into the shapes we want. Many of the iron things we use are made by melting iron and pouring the liquid iron into molds.



The red-hot aluminum is being poured into molds. When it cools, it will harden into solid pieces that have the shape of the mold.

Scientists have spent years and years experimenting to find out how to melt metals and to mold them into different shapes. The Indians found copper long before white people came here, but they did not make much use of it. They could only hammer it into shape with stones. They did not know how to melt it. So they could not pour it into molds to make things of different shapes.

We could not mix metals, either, if we did not know how to melt them. You have often seen pieces of brass. Brass is a bright yellow metal made by melting and mixing copper and zinc. Bronze is made by melting and mixing copper and tin. Bronze will not rust. It is harder than either copper or tin. Statues and other things that are outdoors all the time are often made of bronze.

---

1. *What do we mean by the* melting point *of a solid?*
2. *Why do we sometimes need to melt solids?*
3. *Why would lead be a poor metal to use for making cooking pans?*
4. *Why do we sometimes want to mix metals?*

How are liquids changed to gases?

In winter, people put some alcohol or another liquid in the radiator of an automobile to keep the water from freezing. Perhaps you have heard someone say, "My radiator boiled yesterday, and I suppose the alcohol is all gone. I'll have to get some more."

Do you know what became of the alcohol? Do you know why the alcohol changed to a gas before the water did? If you boil some alcohol, you will understand why the alcohol changed to a gas and left the water behind. If you put a thermometer in water, the thermometer will show 212° F. when the water boils. But if you put a thermometer in alcohol, the thermometer will show 172° F. when the alcohol boils.

No matter how fast a liquid boils, it will not get any hotter than it is when it first begins to boil. When it boils, it is changing from a liquid to a gas just as fast as it can. The temperature at which a liquid boils is called its *boiling point*. The boiling point of water is 212° F., and the boiling point of alcohol is 172° F. Every liquid has its own boiling point.

When an automobile engine runs, the alcohol and water in the radiator both get warm. If they get as hot as 172° F., the alcohol will boil and change to a gas. But the water is not yet hot enough to boil. Some of the water will change to a gas, but it will not change very fast until it boils. It will not boil until it reaches 212° F. So most of the water stays in the radiator long after all the alcohol has gone out into the air.

But, of course, you know that you do not have to boil a liquid to make it change to a gas. Water is always changing from a liquid to a gas, or evaporating. This is what happens when water in an open dish or glass disappears. The water that is in the air is called water vapor. Water vapor is a gas. You cannot see it.

We get some of our supply of salt by evaporating water. The water in the oceans and in some big lakes, such as Great Salt Lake in Utah, has much salt in it. When the water evaporates, the salt is left behind. To get the salt, the water is pumped into large, flat basins. The water evaporates, and the salt can be shoveled up. The picture on the next page shows how salt is taken from the water in Great Salt Lake in this way.

You can do some experiments to find out more about how different liquids evaporate. Take two pans that are just alike and put exactly the same amount of water in each pan. Mark each pan to show just how high the level of the water is. Heat one of the pans slowly. Do not heat the other one. After half an hour look at the pans. Did heating make the

This white material looks like snow. But it is salt that was left when water from Great Salt Lake evaporated.

water evaporate faster in one of them? Why is it important to have the same amount of water in each of the two pans before you begin to heat one of them?

Now get two saucers that are exactly alike in shape and size. Put a tablespoonful of alcohol in one saucer and a tablespoonful of water in the other. Let them stand for an hour. Then measure the liquid in each saucer. Which liquid is evaporating faster? Scientists know that some liquids evaporate faster than others. Does gasoline evaporate more quickly than water? If you do not know, how can you find the answer to this question?

---

1. *Do all liquids boil at the same temperature? Give an example to explain your answer.*
2. *What does* evaporate *mean?*
3. *Will a hot fire make boiling water any hotter than 212°F.? How could your mother save fuel by knowing this?*
4. *Why will clothes dry more quickly if they are hung in the sun than if they are hung in the shade?*

How is water vapor changed to liquid water?

WATER THAT has evaporated into the air can be changed to a liquid again. Do you know how? Here is a picture of a teakettle full of boiling water. Look carefully at the picture. Can you see anything close to the spout of the kettle? This space that looks empty is really filled with steam. You cannot see it, because it is a colorless gas. Steam is very, very hot. It is water vapor that is at the same temperature as boiling water.

When the hot steam gets a little farther away from the hot kettle, it gets cooler and changes into very tiny drops of water again. These tiny drops make the white cloud a short distance from the spout of the teakettle. If you hold a cold plate in this cloud, the plate will soon be covered with water. How does this water get on the plate?

The steam, which is a gas, changes to liquid water when the steam is cooled on the cold plate. The air near the spout of the teakettle is also cool enough to change the steam back into tiny drops of water. We say that the steam condenses. Condense means change from a gas to a liquid. Cooling helps gases condense. Heating helps liquids evaporate.

Air always has some water vapor in it. If the air is cooled enough, some of the water vapor condenses. You may have seen this happen when you made a pitcher of ice-cold lemonade in the summer. The air around the pitcher is cooled. Some of the water vapor in it condenses. Tiny drops of water form on the pitcher. And if you blow your breath against a cold windowpane, the same thing happens. Your breath contains a great deal of water vapor. This water vapor condenses when it strikes the cold windowpane.

---

1. *What does* condense *mean?*
2. *Before water vapor will condense, what must happen?*
3. *Have you ever seen steam? Explain your answer.*

QUESTIONS TO ANSWER

1. If very hot water is poured into a drinking glass, the glass will usually break. Why does this happen? What does this tell you about washing dishes?

2. Baking powder is often mixed in the flour to make biscuits or cake. When the dough is heated, the baking powder forms carbon-dioxide gas. The gas is trapped in the dough. As the dough is heated, it gets larger. Why?

3. Why does the ceiling above a radiator or register get dirtier than the rest of the ceiling?

4. Why do smoke and steam usually go up instead of down?

5. Why does water sometimes collect on windowpanes inside the house when it gets cold outside? Where does the water come from?

6. Wooden wagon wheels usually have iron rims. Before they are put on the wheels, the rims are heated very hot. Then they are slipped over the wheels and allowed to cool. Why are the rims heated before they are put on?

7. Sometimes we keep materials in bottles with glass stoppers. These stoppers often are hard to get out. How could you use what you have learned about heat to help you remove a glass stopper that was stuck tight?

8. In a pond or lake, where will the warmest water be in summer? Where will the coldest water be? Explain your answer.

9. Why can you "see your breath" on a very cold day but not on a warm day?

THINGS TO DO

1. Find out what "dry ice" is. Probably a druggist can tell you. Make a report to the class.

2. Find out one reason why rivets are heated red-hot when they are put into steel beams to hold the beams together.

3. Make a list of some things at home and at school that have been made by changing a solid to a liquid and then letting the liquid cool.

4. When water freezes, does it expand or contract? Make up an experiment to show that your answer is correct.

5. Find out whether water is different from other liquids in the way that it acts when it freezes.

6. If you can get a can of automobile antifreeze mixture, read the directions on it. Tell the class everything you learn about the directions.

7. Make a drawing of a room with a stove at one side. Show by arrows how the air currents move.

8. Make a pinwheel of paper. Hold it over a hot register, stove, or radiator. Why does it turn?

9. Find out how the Fahrenheit thermometer got its name.

★ *In Unit Five You Will Learn* ★

★ *How materials are different from each other* ★
★ *How we can change the characteristics of materials* ★ *What elements are* ★
★ *How elements are joined together* ★ *How we use chemical changes* ★
★ *How we can prevent harmful chemical changes* ★

★ UNIT 5 ★

What Are Things Made Of?

DID YOU EVER find a piece of something and wonder what it was made of? Perhaps it was a stone with bits of white, yellow, and black materials in it. Or perhaps it was a piece of metal that was different from anything you had ever seen before. When you said to yourself, "I wonder what it is made of," you were asking a question that people began to ask many thousands of years ago.

Those people of long ago saw many of the same things happening that you see. They saw a big pile of wood burn and leave only a small pile of gray ashes. They saw bright iron swords turn to a dull brown color when they rusted. And they saw copper kettles change from brown to green. Red, juicy meat that was good to eat on one day would change color and be spoiled a few days later. If they ate the spoiled meat, they often found that it would make them sick. All this made them wonder what things were made of and why they changed.

Over 2000 years ago, a famous thinker lived in Greece. He decided that he knew what things were made of. He said, "Everything in the world is made of air, water, soil, and fire." Why do you suppose he thought that? He knew that living things need air and water to live and to grow. So he decided that many things must have air and water in them. He knew that plants grow out of the soil and that animals need plants for food. He thought that there must be some soil in all living things.

Fire was a mysterious thing that no one could understand. It seemed to come out of wood, cloth, and other materials when they burned. So the wise man decided that there must be fire in many things in the world, too.

The famous Greek thinker of long ago thought that everything in the world must be made of these four things—air, water, soil, and fire. For hundreds of years, people believed that this was true.

Then people began to look at things

more carefully and to do experiments. So they began to find the right answer to the question "What are things made of?" We still do not know all of the answer to this question. But scientists are working all the time to find out more about how things are made.

When you study this unit, you will learn more about materials than the wisest men knew in the days of the great Greek thinker. You will learn what things are made of and what happens when materials change. A good way for you to begin is to look at some of the things that you see and use every day. The many things that you find out about materials will probably surprise you.

How are materials different from each other?

SUPPOSE EACH ONE in your class brings two or three things made of different kinds of materials to study. Here are some of the things that one science class brought—a piece of coal, a lump of wax, vinegar, water, buttons, wood, stone, rope, milk, nails, a tin can, maple syrup, salt, an apple, and some sugar. Henry even brought a bottle of carbon-dioxide gas. His father owned a drug store, and he told Henry that carbon dioxide is used to make the "fizz" in soda water. He took some of the gas from a big steel tank and put it into a bottle so that Henry could carry it to school.

When you have your collection of materials ready, separate them into three groups—solids, liquids, and gases. Then look at each kind of material carefully to find out what it is like. Look for things that will help you describe the materials to someone else. Feel them, look at them, smell them, and squeeze them. You may try to pull them apart and try to bend them. Ask your teacher which materials are safe to heat and taste. But you must be careful not to heat or taste materials unless you know what they are. The material might explode, or it might be poisonous. Never heat or taste any material unless your teacher says that it is safe to do so.

While you are looking at these materials, write on the blackboard or on a piece of paper the different words you would use to tell what the materials are like. When you get through, you should have a list somewhat like this one that one class made.

Hard
Soft
Springy
Brittle
Sticky
Watery
White
Black
Sour
Sweet
Colorless

Rough
Smooth
Easy to melt
Hard to melt
Can be stretched
Can be bent
Can be squeezed
Strong
Weak
Shiny
Dull

What materials do you see in this picture? What are some of their characteristics?

Write this sentence at the top of your list. "These are some of the *characteristics* of materials."

Do you know what the word characteristics means? When we want to describe a person, we tell what his characteristics are. Perhaps you have blue eyes, dark-brown hair, freckles on your face, and a little scar on your finger where you cut it last month. These are some of your characteristics. They describe you. Other people know who you are by these characteristics. Each kind of material has characteristics of its own that tell us what the material is like.

The way we use a material depends on its characteristics. What characteristics of glass make it good for windows? You can probably answer this question very easily. First of all, you know that you can see through some kinds of glass. Then, too, glass will not soak up water. If it did soak up water, windows would get soaking wet every time it rained.

The boys and girls in the science class were examining all the materials they had brought to class. They wanted to find the important characteristics of each material. They stretched a rubber band, and the band

What happened to the blue litmus paper when the girl put one end into some vinegar?

snapped back when they let go of it. They had found that rubber is *elastic,* or springy. They squeezed a piece of cotton and a sponge and saw that they could make these take up less room. This showed them that cotton and sponges could be *compressed,* or made smaller by squeezing.

As the boys and girls were finding the characteristics of the different materials, something funny happened. Jane saw some brown liquid in a jar. She asked the teacher if it would be safe to taste it. When Jane was allowed to taste it, she swallowed a spoonful of it. You should have seen her face! The liquid was vinegar, and Jane learned one of its main characteristics. It is *sour.*

The boys and girls knew that it was dangerous to taste a liquid if they did not know what it was. The liquid might be poisonous. So the boys and girls asked if there is a safe way to find out whether anything is sour.

"Yes, there is a safe way," said the teacher. "Everything that is sour has *acid* in it. I'll show you how a scientist tests a material to see whether it has acid in it. He doesn't have to taste it."

She got a strip of paper called *litmus paper.* This litmus paper was blue. She put one end of the litmus paper in a small amount of vinegar. When she took it out, the end that had been in the vinegar had turned from blue to red. A scientist knows that anything with acid in it will turn blue litmus paper red.

The boys and girls tested other things. They cut a lemon in half and put one end of the blue litmus paper against the cut surface of the lemon. The lemon turned the paper red.

How can you find out which of these materials have acid in them?

This showed that the lemon had acid in it, too. Then they mixed some baking soda in water. When the blue litmus paper was put into this, it did not turn red. Does baking soda have acid in it?

Safety rules for handling materials

1. Never taste anything if you do not know what it is.
2. Never heat materials unless you know that they will not explode.
3. Never mix materials that may explode or burst into flame.
4. When you are heating a material, clear away everything that may catch fire.
5. If you get an acid that burns on yourself or your clothes, wash it off quickly. Baking soda dissolved in water is good to use.

---

1. *What characteristics of iron make it a good material for bridges?*
2. *Tell how you would find out whether oranges and apples have acid in them.*
3. *What characteristics of wood make it a good material for furniture?*
4. *Compare the characteristics of cellophane and tissue paper. Why is cellophane better than tissue paper for wrapping food?*

How can we change the characteristics of materials?

SUPPOSE YOU TAKE two or three of the materials that you have brought to school and try to think of ways in which you can change some of their characteristics. How could you change the characteristics of water? Right away, you may think of freezing it and of boiling it. When you freeze it, it changes from a liquid to a solid. When you boil it, it changes from a liquid to a gas. Solid blocks of wax or paraffin like those in the picture can be changed to a liquid by heating them. A piece of lead will change to a liquid if you make it hot enough.

But what happens to liquid wax when it is poured onto some cool jelly? And what happens to melted lead when it cools? Does the water, the wax, or the lead change into a new material when it is heated or cooled? No, it does not. The lead is still lead, the wax is wax, and the water is water, no matter whether they are solid, liquid, or gas. A change like this is called a *physical change.* The material changes its form or shape, but it does not change into a different kind of material.

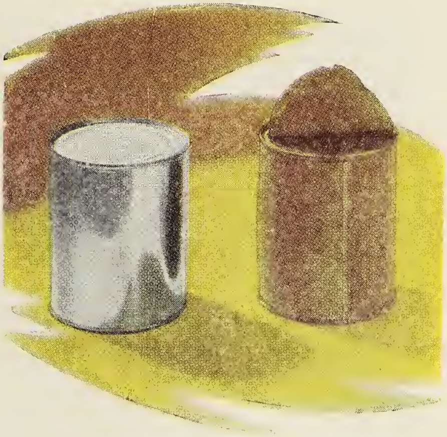
You know that some materials can be dissolved in liquids. You have dissolved sugar in water when you were making lemonade. And probably you have dissolved salt in water, too. If you tasted the water, you could tell that the sugar or the salt had not been changed into something else. They were still the same materials, even though they had been dissolved in water. The change that takes place in materials when they dissolve is a physical change.

Now let us do an experiment to show a very different way in which we can change materials. Fill a test tube about one-fourth full of sugar. If you do not have a test tube, use a metal lid from a jar or can. Heat the sugar for several minutes. Watch closely to see what happens. The white sugar turns to a brown liquid. Then you can see a white material coming from it. After a few minutes, a black material is all that is left. What do you think happened?

You have changed the sugar into something entirely different. The material left in the test tube does not have any of the characteristics of sugar, because it is no longer sugar. Sugar is white, but this new material is black. If you cool this black material and taste it, you will find that it is not sweet. When you dissolve sugar in water, you do not change it into anything else. But when you heat sugar, you change it into a different material.

You have often seen other changes that make new materials. You have seen bright, shining iron or steel changed to a brown, rusty material. Perhaps you have lost a pocketknife and have found it out in the yard several days later. You can easily rub off some of the brown rust with your fingers. Or perhaps you have seen an old tin can that has been outdoors for a year or more. You know that such a can is full of holes and that it is soft and crumbly. We say that the can has rusted. A new material has been made out of the material of the can.

The changes that happen when sugar is heated and when iron rusts are very different from the changes that happen when you melt wax or lead or when you evaporate water or dissolve salt in water. The heated sugar changes into something else. And the rusted iron becomes something different. New kinds of materials are made.



These new materials are different from the old materials. This kind of change is called a *chemical change*. When a chemical change takes place in a material, it changes to a new material. This new material has characteristics that are different from the characteristics of the old material.

You have seen chemical changes going on around you ever since you were old enough to notice them. In autumn, when leaves turn from green to red, yellow, orange, and brown, a chemical change has taken place in the leaves. Different materials have been made inside the leaves. When you find a piece of soft, brown, crumbly, decayed wood, you are looking at something that has been made by a chemical change. The hard yellow or

What chemical changes are taking place in this picture?

white wood that could have been made into a piece of furniture has been changed into something else.

Every time you light a fire, you start a chemical change. Burn a small splinter of wood in a metal pan. Be very careful to see that there is nothing near the pan which can catch fire. Watch the piece of wood change. After part of the splinter has burned, put out the flame. What has become of part of the wood? What color is the stick where it was partly burned?

You can see that a chemical change has taken place, because the gray ashes and the black material are very different from the piece of wood. A big piece of hard, black coal changes into a little pile of soft, gray ashes when it burns. The ashes are very different from the coal that burned.

Chemical changes are taking place inside your body all the time. Your body is like a chemical factory. Some of the food that you ate today is being changed into part of you. This is a chemical change. Put a small piece of bread or a cracker into your mouth and chew it for a long time. How does the taste change? If you hold it in your mouth long enough, the starch in the bread or the cracker will change into something that tastes sweet. This is one of the chemical changes that make the food ready for use in your body.

Every day, meat, potatoes and other vegetables, milk, fruit, eggs, and other foods are being changed into blood, muscles, bones, and teeth. You could not live if the food you ate were not changed into part of you.

Remember that there are two kinds of changes that can take place in materials.

1. When a material changes in form or shape but does not change into a new material, scientists say that a physical change has taken place.
2. If a material changes to a new material, they say that a chemical change has taken place.

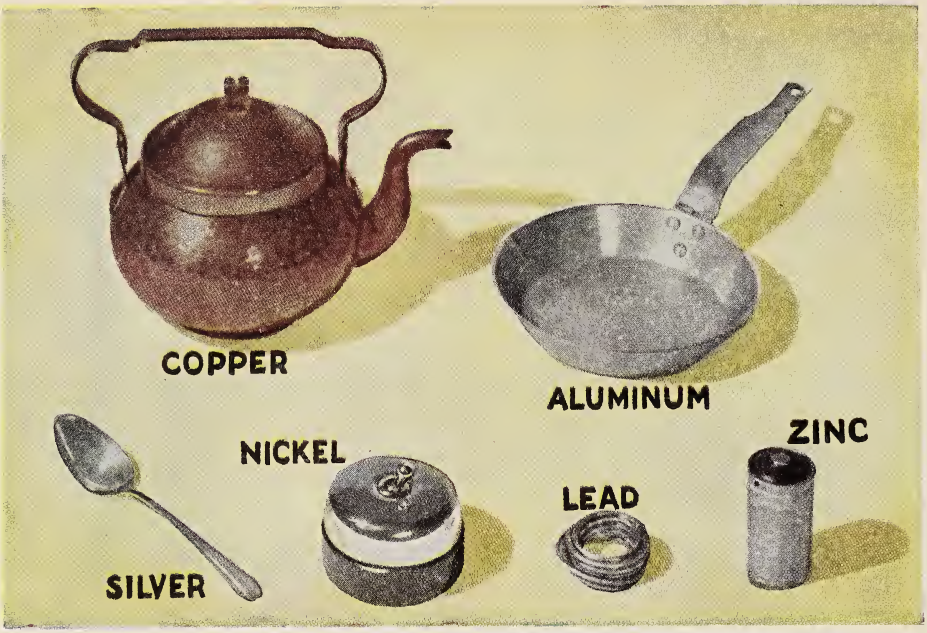
---

1. *How is a chemical change different from a physical change? Give an example of each kind of change.*
2. *When you peel potatoes, do you cause a chemical change? Explain your answer.*
3. *Why is burning a piece of wood a different kind of change from melting a piece of iron?*
4. *What do chemical changes do to materials?*
5. *How are the characteristics of wood different from the characteristics of wood ashes?*
6. *After a chemical change has turned the green leaves to their autumn colors, what characteristics of the leaves are still the same? What characteristics are different?*
7. *Why are chemical changes important to you?*

What are elements?

WHAT DO YOU think happened to the sugar when you heated it? And what is the brown material that you rub from a rusty knife? Before you can answer these questions or understand the other chemical changes that take place around you, you will have to know what *elements* are and what we can do with them.

You remember that a famous man of long ago thought that everything in the world was made of just four things—air, water, fire, and soil. He called these things elements. But scientists now know that air, water, fire, and soil are not elements at all. They have found 98 different elements. All the different things in the world are made of these 98 elements.



Each of these things has in it a large amount of the element named near it.

You have seen some of these elements. You have seen iron, gold, copper, lead, silver, nickel, and aluminum. Perhaps you have also seen mercury, or quicksilver, and sulphur. These are elements, too. You will never see some of the 98 elements, because they are colorless gases. The oxygen in the air is one of these colorless elements. The air also contains nitrogen and small amounts of several other colorless gases that are elements.

You probably will never see some of the other elements, because they are so scarce. Some elements are so very scarce that you would never find them unless you went to some great science laboratory to see them.

Collect as many different elements as you can find. Label them and put them on a shelf for an exhibit. One science class was able to find eleven elements. They had lead, iron, copper, gold, silver, nickel, aluminum, and sulphur. To get two other elements, zinc and carbon, one of the boys took an old electric cell apart. The thin sheet of gray metal around the cell was zinc. The black rod in the middle was carbon. One boy brought an electric-light bulb. His father had told him that the wire inside was made of an element called tungsten.

Do you know why we call these materials elements? If you look in the dictionary, you will find that element means the simplest material from which other materials are made. Iron, silver, copper, lead, and the other elements are the simplest materials in the world. You can take one of these elements, such as iron, and crush it, grind it into the finest kind of powder, heat it, or dissolve it in liquids. But you cannot find any material in it except iron. For this reason, we call it an element. An element is made only of itself, not of two or more materials put together. Iron is made only of iron. Gold is made only of gold.

All the things in the world are made of these 98 elements. The next time anyone asks you the question "What is it made of?" you can be sure you are right if you say, "It is made of one or more elements." Some materials, like water, carbon dioxide, and salt, are made up of only two elements. Others, like sugar, washing soda, and alcohol, are made of three elements. There are many materials that are made of more than three elements. Pure baking soda has four elements in it.

---

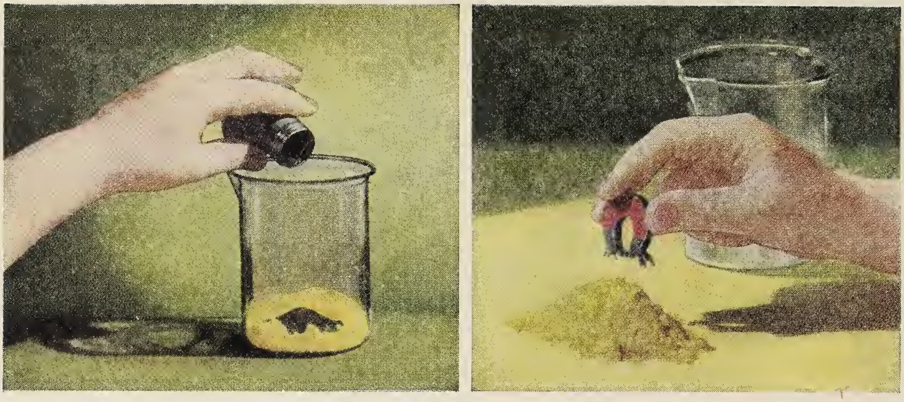
1. *How is an element different from other materials?*
2. *Why can some of the elements not be seen?*
3. *How many elements have scientists found?*
4. *When is a material not an element? Give some examples.*
5. *Name some elements you have seen.*

How are elements joined together?

THINK CAREFULLY again about what happened to the sugar when you heated it. A black material stayed in the test tube. A white material went out of the test tube. Do you think that sugar is an element? It looks as if the sugar has been changed into other materials. That is exactly what has happened. The black material left in the test tube was the element carbon. The white material had two elements in it—hydrogen and oxygen.

So you see that sugar is a material that is made of simpler materials. Sugar is a *compound.* It is made of three elements—carbon, hydrogen, and oxygen. A compound is a material made of different elements joined together.

When the boys and girls in the science class were talking about this,



Have the sulphur and iron combined to make a new material? Why do you think so?

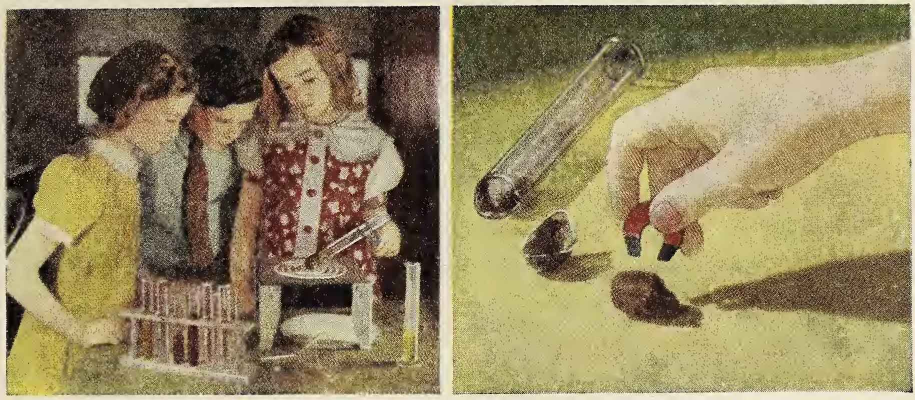
Nancy said, "I think I saw some carbon this morning. I was helping my mother get breakfast, and I forgot about the toast in the oven. When I looked at it, the toast was black. So I think that was carbon."

Two colorless gases and a black solid can make white, sweet sugar. This happens when a chemical change takes place. A chemical change makes an entirely different material. The new material has characteristics that are different from the characteristics of the elements that joined to make it.

Water is made of two elements—hydrogen and oxygen. These elements are colorless gases. When hydrogen and oxygen are joined together in just the right way, they form the liquid water. The characteristics of water, which is a liquid, are different from the characteristics of hydrogen and oxygen, which are gases.

Scientists have found only 98 elements. But these elements can be joined together, or *combined,* to make many different kinds of materials. No element will combine with all the other elements, but most of the elements will combine with several other elements to make compounds. Some compounds are made of only two elements. Others are made of several elements.

Whenever compounds are made, the elements do not just mix with each other. They combine with each other to make the compound. Take some powdered sulphur and some powdered iron. Shake the two elements together in a test tube. You are not making a compound. You are making a mixture. Pour the mixture out on a table and hold a magnet in the mixture. The fine pieces of iron stick to the magnet. The sulphur is left. Why does this show you that you did not make a compound?



What has happened to the iron and sulphur now? How do you know?

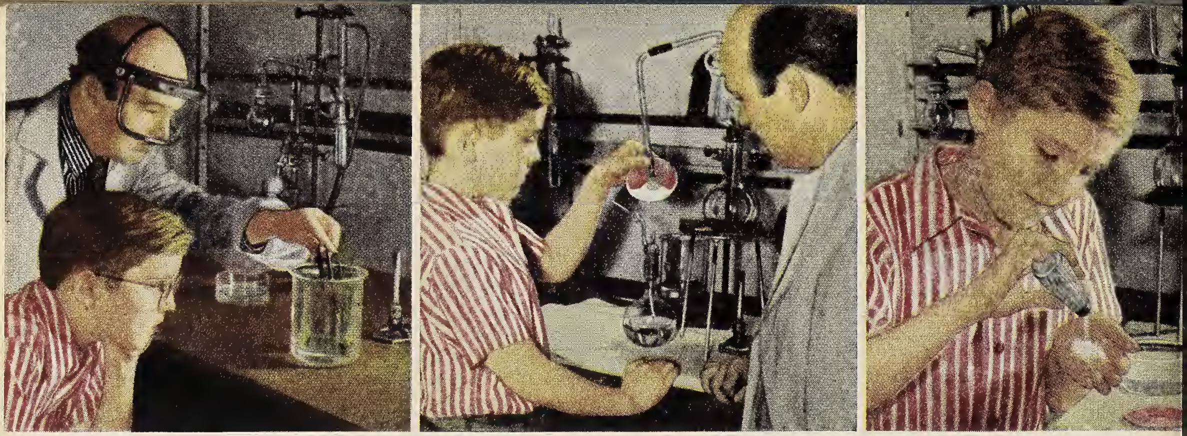
Put the mixture back in the test tube and pour water into the test tube. Still you have not made a compound. The sulphur rises to the top of the water, and the iron sinks to the bottom. The two elements have not been combined with each other. They have only been mixed with each other.

~~Let us see if we can make these two elements combine.~~ Put exactly twice as much sulphur as iron into a test tube and stir them together. Hold the test tube over a flame and heat the two elements until they are very hot and seem to be combined. Cool the material and remove it from the test tube. You may have to break the test tube to get the material out. Wrap a cloth around the test tube first so that you will not get cut.

Test the material with the magnet. Does the magnet still pick up the iron? Put the material in water. Does it sink? The iron and sulphur have combined to form a compound that is different from either iron or sulphur. So the magnet can no longer attract the material. This material is no longer just iron and sulphur. It is a compound called iron sulphide.

Now let us learn about some other compounds. The element iron is a hard, silver-gray metal. When it rusts, it combines with some oxygen from the air and changes to a soft, crumbly, brown material. When someone asks you what iron rust is, you can tell him that it is a compound made of iron and oxygen. Bring a piece of rusty iron to school and look at it. Notice how soft the rusted part is.

Did you ever see copper that had been outdoors for a long time? It had probably turned to a dull, greenish color. If you scraped the dull material off with a knife, you found the shiny copper underneath. The outer



The picture on the left shows how a piece of sodium sends up a flame when it is dropped into water. In the center, you can see how the greenish gas, chlorine, takes the color out of a red piece of paper. But when these two elements combine to make a compound, you can have salt coming out of a shaker.

covering was a material made of copper, carbon, and oxygen. These three elements combined to make a material that was not like copper, carbon, or oxygen. It was a compound of copper, carbon, and oxygen called copper carbonate.

Every day you use a compound that is made of two very dangerous elements! This compound is white. You probably use it on an egg at breakfast. Your mother uses it in cooking almost everything. It is salt! Salt is made of two elements. One of these elements is a bright, soft, silvery metal called sodium. If you put a piece of it on your tongue, it would burn your tongue badly. The other element is a greenish gas called chlorine that has a very bad odor. It is poisonous!

But when these two elements are combined by a chemical change, an entirely different material is made. This new material is not poisonous, it will not burn your tongue, it does not have a bad odor, and you need it in your body. The chemical change makes a compound that is very different from the two elements that are in it. Scientists call it sodium chloride, but we call it salt.

If your house is painted white, it may be covered with a compound made of the two elements zinc and oxygen. When iron and oxygen combine, they make the brown material that we call iron rust. But when zinc and oxygen combine, they make a compound that is a white solid called zinc oxide. It is ground into a fine powder and mixed with oil to make one kind of white paint. It is also used to make a kind of salve.

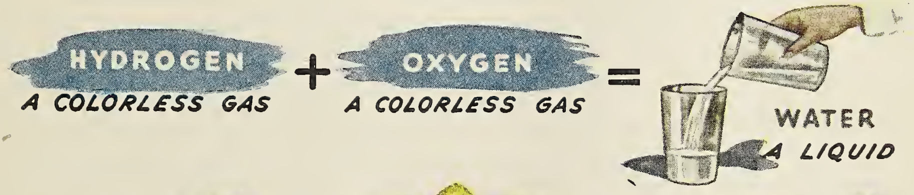
Did you ever hear of a kind of paint called red lead? Perhaps you have seen men painting iron bridges or other iron with this bright red paint. It is made of a compound of lead and oxygen.

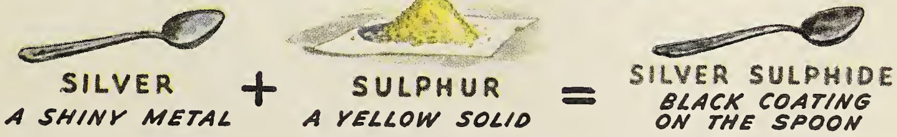
Everything in the world is made of elements and compounds. So, of course, your body is made of elements and compounds. Scientists have figured out that there is enough iron in a person's body to make a good-sized nail. There is enough phosphorus in your bones and teeth to make a match. Of course, you know that the iron in your body is not solid iron like a nail, and you know that the phosphorus will not blaze up like a match. The phosphorus and iron are in compounds in your body.

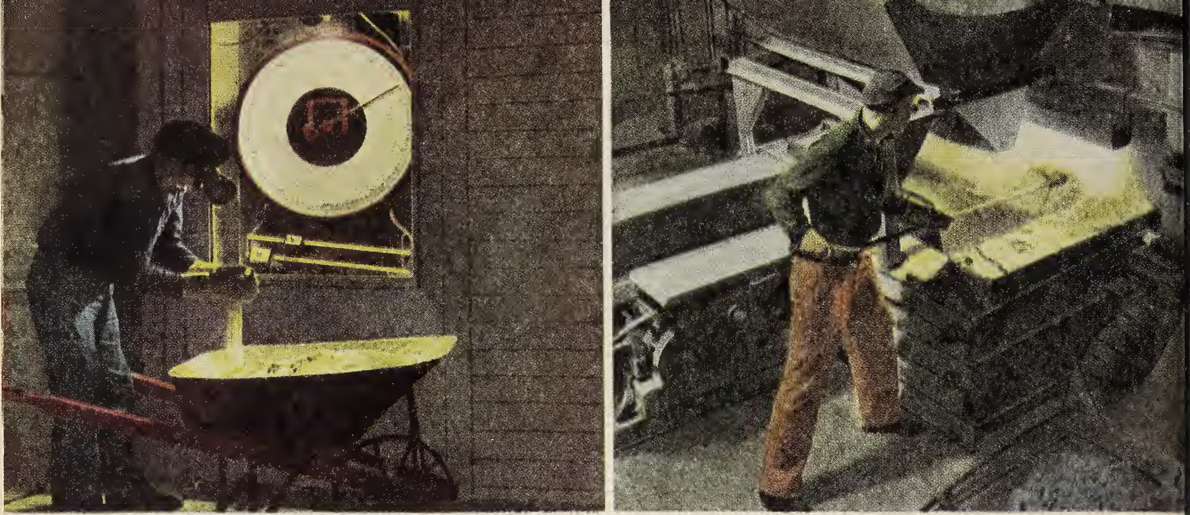
Your bones and teeth have in them another element called calcium. Milk is good food for making bones and teeth because it has much calcium in it. Calcium combines with phosphorus and oxygen to make a compound called calcium phosphate. Your body is made up of many other elements and compounds. You will learn more about them later.

---

1. *Which is the best statement? A compound is made of (a) one element, (b) two elements, (c) three elements, (d) more than one element.*
2. *How are compounds different from elements?*
3. *Many chemical changes are mentioned in these pages. Make a list of the ones you know about. After you have made your list, complete this sentence: "I know that these are chemical changes because ____________"*
4. *Explain the difference between mixing two materials together and combining two materials. How could you do an experiment to show what this difference is?*
5. *Do you think that a chemical change takes place in milk when it sours? How could you use litmus paper to show that your answer is correct?*







In the picture on the left, sand and the other materials for making glass are being weighed. In the other picture, the mixture that will be changed into glass is being put into the oven to be melted.

How do we use chemical changes?

You have learned that chemical changes are happening all around you and that they are very important. All over the world today, scientists are studying the things that are in the earth and on the earth. They are finding ways of putting elements together to make new compounds and of taking compounds apart to make many kinds of new materials. These new materials are different from the elements and compounds that were used to make them. The new materials have characteristics that make them more useful to us.

Let us see how chemical changes are used to make some of the materials we need for building houses. The window glass that is letting light into your schoolroom was made mainly from sand. It is easy to see that sand must be changed before it can be made into glass. You cannot see through sand, but you can see through the glass. Scientists have found out how to make glass by mixing some other materials with sand. When this mixture is heated very hot, it melts. Then chemical changes make it into a new material with new characteristics. This is glass.

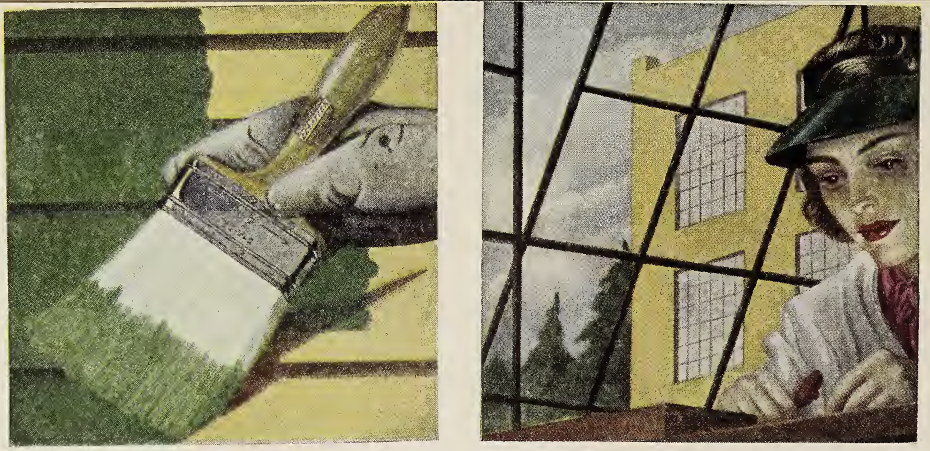
Streets and sidewalks are often made of concrete. Concrete is made by mixing the right amounts of water, sand, and cement together. As the mixture hardens, chemical changes take place that produce an artificial stone. Walls of buildings are plastered. Plaster is made from lime and sand. When water is added to lime, it gets very hot. You can see it bubble as the chemical change takes place.

Many of the things you use every day have been made by chemical changes. Paper is made by a chemical change. You cannot find paper growing, and you cannot dig it from the ground. Most paper is made from trees. The trees are cut, and the wood is ground up into a pulp. Materials are then added to the pulp, and a chemical change takes place. This change makes the material for paper. You could never make a book from the wood as it comes from the tree. But after the chemical change takes place, a new material is made. This new material is paper for books, newspapers, magazines, and many other things.

You have probably heard people talk about things made of *plastics*. Plastics are materials that can be formed, or molded, into different shapes when they are hot. When they cool, they get hard and keep these shapes. Plastics are made from other materials by chemical changes. There are too many plastics to name them all, but you already know the names of some.

Celluloid was one of the first plastics. Ping-pong balls are usually made of celluloid. Many things, especially foods, that you buy at the store are wrapped in *cellophane*. Perhaps you have some dishes made of *bakelite* or a comb made of a clear, transparent material called *lucite*. Fountain pens and combs are often made of lucite or some other kind of plastic. Plastics are used for much bigger things, too. They are very strong and do not break easily. Parts of airplanes, automobiles, furniture, and even water pipes are made from plastics.

These pictures show you three steps in making paper. In the picture on the left, the logs are being sent to the grinders to be ground into wood pulp. The center picture shows what wood pulp looks like before it is made into paper. The last picture shows the paper.



The bristles of the paint brush are made of nylon. Another kind of plastic was used instead of glass in this window.

Some plastics are drawn out in threads and woven into cloth. *Rayon* and *nylon* are plastics of this kind. If your mother is wearing a dress made of rayon, she is wearing cloth that was probably made from wood. If she has some nylon stockings or a nylon blouse, she is wearing cloth made from coal, air, and water.

Besides cloth for clothes, nylon is used for many common things. Perhaps you brush your teeth with a toothbrush that has nylon bristles on it. When you go fishing this summer, you may use a nylon fish line. Nylon fish lines are so strong that you will not lose a big fish because your line breaks.

Your mother uses chemical changes at home, too. When she bakes a cake, she often uses baking powder to bring about a chemical change that makes the cake light. If she uses sour milk when she bakes a cake, she uses another chemical change. She adds baking soda to the sour milk, which has acid in it. When she puts the baking soda into the sour milk, a chemical change takes place. A gas is formed that makes the cake light.

Your mother then bakes the cake. The heat expands the gas, and the cake rises. If she burns gas, wood, coal, or oil in the stove, she is using the chemical change of burning to get the heat that bakes the cake.

---

1. *Make a list of building materials made by chemical changes.*
2. *Make a list of clothing materials made by chemical changes.*
3. *Which of these materials are made from other materials?*
   Wood Wool Aluminum Copper Iron Steel Glass
   Cotton Bricks Plaster Rubber Leather Linen Gasoline
4. *How do you know that cooking often causes chemical changes?*

The sailors are kept busy painting the funnels and other metal parts to keep them from rusting.

How can we prevent harmful chemical changes?

PERHAPS YOU THINK that all chemical changes are useful to us. But if you think carefully, you may find that some of them are harmful.

Can you think of some chemical change that you may want to stop? You probably will think of rusting. Bridges, automobiles, skates, bicycles, nails, and other things made of iron and steel would soon be useless if we did not do something to keep them from rusting. Do you know how to keep them from rusting? If you think carefully, you will say that we must keep oxygen away from them. But how can we keep oxygen away from them? Just cover the iron and steel with something that will keep away the oxygen that is in the air. Paint is used to cover these metals.

Try this experiment and see what happens. Put some iron nails or some pieces of steel wool in a dish and keep them damp by sprinkling them with water. Put some other iron nails or steel wool in a dry dish. Look at them a few days later. Which ones are rusty?

Iron or steel rusts more quickly when it is damp. That is why we must be careful to keep tools and machines made of iron or steel dry.

One way of keeping foods is to dry them. In this picture, apricots are being dried in the sun. Can you think of some other foods that are preserved by drying?

Perhaps you wipe your skates with oil or grease to keep them from rusting during damp weather. The oil or grease keeps both air and moisture from the skates. Steel tools are often covered with oil or grease to keep oxygen and moisture away from the metal.

If you touch a tin can with a magnet, you will find that the magnet attracts the can. Tin, as you know, is not attracted by a magnet. So how do you explain what happened? Tin cans are not made of tin. They are made of steel. Steel rusts easily, but tin does not rust. So the steel can is coated with a layer of tin to keep the oxygen away from the steel.

Ash cans and garbage cans are usually made of a material called galvanized iron. This is steel covered with a layer of zinc. Zinc does not rust. We can stop harmful chemical changes by keeping materials that cause chemical changes away from materials which we do not want changed. This is what we do when we paint or varnish woods and metals and when we put a layer of some other metal over iron or steel.

Perhaps you have noticed that cans or bottles which have a powder in them are often labeled "Keep dry." Let us see what happens to some baking powder when it is not kept dry. Put a spoonful of baking powder into a cup or glass. Now add a spoonful of water. At once, something happens. The mixture begins to fizz. Hundreds of tiny bubbles of gas are given off. A chemical change is taking place. As long as the powder was dry, no chemical change took place. As soon as water was added, the chemical change started. So when you see a bottle labeled "Keep dry," you know what you should do to keep a chemical change from taking place.

Another chemical change that we usually do not want is the spoiling of food. Food is spoiled when bacteria grow in it and cause a chemical change. Bacteria grow best where it is warm. So keeping food cool is one of the best ways to keep it from spoiling.

Milk will sour very quickly unless it is kept in the icebox. But it will stay sweet for several days if it is kept cold. The decaying of meats and vegetables is another chemical change that we do not like to have happen. So we keep these foods in the icebox to prevent them from changing.

Sometimes we want to keep food fresh for a long time. We may want to ship it to all parts of the country, or we may want to keep it to use later. One way to do this is to freeze food. Freezing keeps the bacteria from growing. As long as the food is kept frozen, it will not spoil.

You remember that bacteria are tiny plants. Like all plants, they need water to grow. So keeping water from them is another way to keep them from growing in food. Many foods are preserved by drying. Prunes, apricots, and other fruits are often dried. Can you think of some other foods that are preserved this way?

Did you ever have some of your colored clothes fade? The colors changed from bright to dull. If you have wallpaper on the walls in your home, look behind some picture that has been hanging in the same place for a long time. Is the color of the paper behind the picture the same as the color of the rest of the paper? What do you think makes the wallpaper change color?

Many materials fade because they are in the light. Sunlight makes chemical changes in the coloring material that was used to color the cloth or the paper. Many medicines are put in dark bottles to keep out the light that may cause chemical changes.

---

1. *How can you prevent chemical changes that take place because of the oxygen in the air?*
2. *What are two ways of preventing chemical changes in food?*
3. *Name two chemical changes that are harmful. Explain why you think they are harmful.*

QUESTIONS TO ANSWER

1. Name two things in your schoolroom that have been made by a chemical change. Name one thing that your mother uses which is made by a chemical change.

2. Why are chemical changes important to us?

3. The picture on the left on this page shows the bubbles of gas in a cake that is baking. What two kinds of changes in materials do we use when we bake a cake? Explain your answer.

4. Long ago, people did not know about elements and compounds. Could they explain rusting, decaying, and the souring of milk?

5. Suppose you heated a material in a test tube and could not see any change in it. Would you then be sure that the material was an element?

6. Do you think that there are more compounds in the world than elements? Explain your answer.

7. When colored cloth is washed, it sometimes loses its color. What do you suppose has happened?

8. Tell something you have done to prevent a chemical change.

9. The picture on the right on this page shows some cattle that are feeding. Later, they will be used for meat. Explain how chemical changes help us get our meat supply.

10. You can buy flour that is all ready to use for making pancakes. The directions on the package tell you to keep it dry. Why do you think this is important?

11. When we put sugar into lemonade, do we make a chemical change?

THINGS TO DO

1. Find out more about elements. Which ones are the most common?

2. Read about some scientist who discovered one of the elements and make a report to your class.

3. Go to a store. Make a list of the things you find that have been made from other materials.

4. Find out what these materials are made from—gasoline, artificial rubber, perfumes, paint, kerosene, dyes for coloring.

5. Make a list of rules for safety in doing experiments. Put the list on the bulletin board.

6. Find out what elements and compounds are found in the air.

7. Put sugar and salt together. Do they make a compound? Or are they just mixed together? How do you know?

8. Is black soil a mixture of materials or just one compound? To answer this question, put about three inches of black soil in a tall glass. Fill the glass with water. Then cover the top and shake the glass until the soil and water are well mixed. Allow it to stand for several hours. What do you see in the glass?

★ *In Unit Six You Will Learn* ★

★ *What we need to make a fire* ★ *What fires need to keep them burning* ★
★ *What happens when things burn* ★ *How we can conserve our fuels* ★
★ *What we can do to prevent fires* ★ *How we can put out fires* ★

★ UNIT 6 ★

How Do We Control Fire?

ONE SPRING DAY, the Bates family was having a picnic in the woods. Betty helped her mother spread a big cloth on the grass near a little stream. Then they set the food from their picnic basket on the cloth.

"When do we eat?" asked Bill. "I'm hungry."

"So am I," said his father, "but those 'hot dogs' we brought won't taste good if they're cold. We'll have to cook them first. You can help me make a fire."

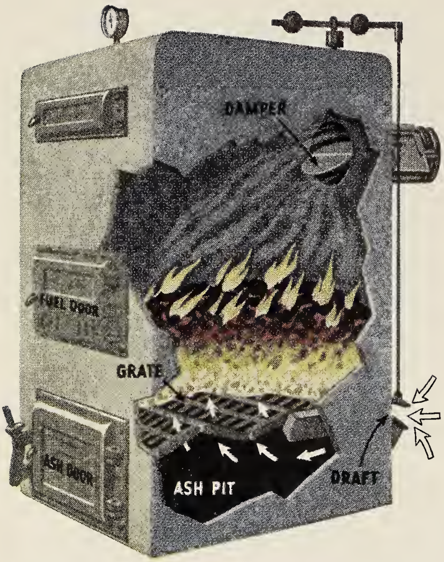
Bill thought it would be fun to cook outdoors. He ran off to get some twigs and branches. Soon he came back with his arms full. His father was getting a place ready for the fire. Bill and Betty watched him work.

"When we make a fire in the woods," he explained, "we must be sure that it will not spread. So first we find a spot away from bushes and trees, and we clear away the dead leaves and dry grass. Then we can start building the fire."

On the bare ground, Mr. Bates made a pile of little twigs. Then he put some bigger twigs and branches on top. The pile of twigs and branches looked somewhat like an Indian wigwam. "We put the little twigs on the bottom, because they catch fire more easily than the big ones do," he went on. "And we pile them up like this so that the air can get in and around them.

"Now we're ready to start the fire. The wind is coming from the east. So we will light the fire on that side. We always light a fire on the side toward the wind. Then the wind blows the flames up through the pile of twigs and branches."

He struck a match and lit the bottom twigs. When a good fire was burning, the Bates family cooked their "hot dogs" and then sat down to eat. They watched the fire burn down to a heap of ashes. After the meal, it was soon time for them to start home.



Mr. Bates' furnace looked very much like this. The firebox is the place where the fuel is burning.

"Before we leave," said Mr. Bates, "we must be sure the fire is out. Betty can help me cover the hot ashes with sand and dirt. Bill, you get a pail of water from the stream. We'll pour it over the ashes, too. Then we'll know they can't blaze up again and set the woods on fire."

By the time the family got home, it was much colder outdoors. "I shouldn't have let the fire in the furnace go out," said Mr. Bates. "Now I'll have to make another fire. This must be my day for making fires."

Betty and Bill watched their father start the fire in the furnace. He opened the top door and looked in. " I'll have to get some of these ashes out first," he said. He moved a handle back and forth, and the ashes fell into the space below. When the children looked into the furnace, they could see some iron bars moving.

"That is the grate," their father said. "As I move this handle, the bars move from side to side. Then the ashes can fall through the grate into the ash pit below. Do you see the holes in the grate? They let air come up from below."

Now Mr. Bates put some paper, some small pieces of wood, and a few larger pieces of wood on the grate bars. He also put a little coal on top. "I don't build a wigwam of sticks as I did in the woods," he said, "but I do lay the wood so that the air can get in and around it. Now let's look at the draft and the damper. I open this draft under the grate to let air in. Then I turn this damper in the pipe to let out smoke and gases from the fire."

He lit the paper. The small pieces of wood and then the larger pieces began to burn. At last, the coal caught fire. "Coal won't burn until it is very hot," he explained. "When the coal is burning well, I can put in some more. Then I can close the draft and the damper a little. If I leave them wide open, the coal will burn up too fast. And most of the heat will go up the chimney. That would waste a great deal of coal."

What do we need to make a fire?

YOU HAVE READ about making a fire in the woods and about making a fire in a furnace. Let us stop and think over what we must do to make a fire in either place. What do we need to start a fire?

Of course, to make a fire, we must first have something that will burn. Some materials will burn, but others will not. You know that paper, cloth, wood, and coal will burn. So will oil and gas. But water, sand, iron, glass, stone, and brick will not burn. We cannot use them to make a fire. Materials that will burn are called *combustible* materials. So you see that the first thing we need for a fire is a combustible material.

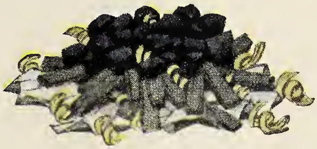
Not every material that will burn catches fire easily. You cannot light a piece of coal with a match. To start a fire, we need a material that will catch fire easily. Paper, cloth, dry twigs, leaves or grass, wood shavings, and little sticks of wood are all materials that catch fire easily. We can use them to start a fire.

Materials that catch fire easily are those that need only a little heat to make them burst into flame. Every combustible material must be heated to a certain temperature before it will catch fire. Scientists call this the *kindling temperature*. If a material catches fire easily, we say that it has a low kindling temperature. A great deal of heat is needed to make coal catch fire. So coal has a high kindling temperature.

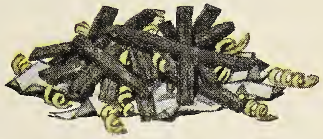
A burning match will light some paper or wood shavings. It gives enough heat to make them catch fire, because they have a low kindling temperature. Burning paper or shavings will make some sticks of wood hot enough to burst into flames. Then the heat from the blazing sticks will make a piece of coal catch fire.

When we make a fire, we put the materials that catch fire easily on the bottom. Above them, we put the materials that need a little more heat to

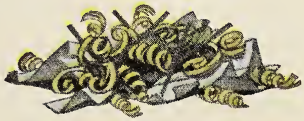
3

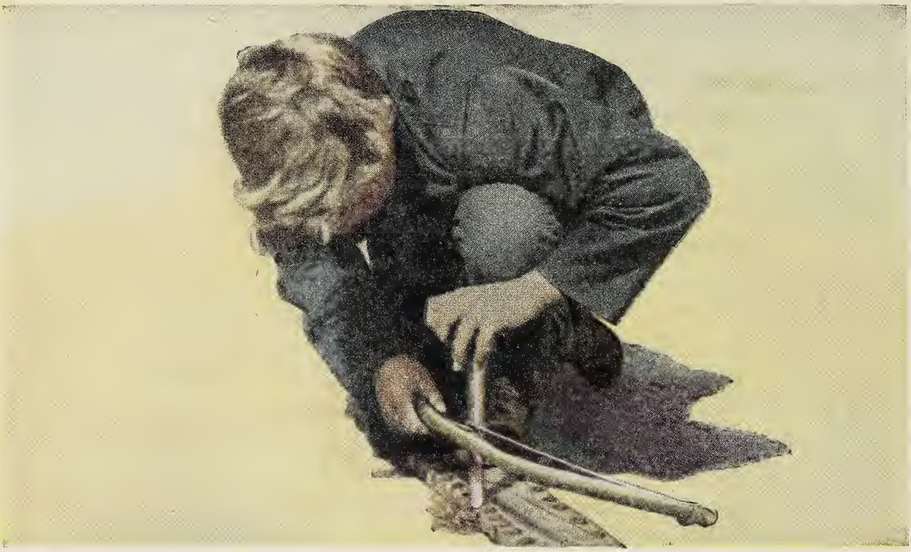


2



1





start them burning, and so on. When we light the materials on the bottom, they burst into flames. The heat from them passes up through the other materials and makes them hot enough to burn. Then they burst into flames.

So far, we have seen that there are two things we need to make a fire. First, we need to have a combustible material. Second, we need to have this material heated to its kindling temperature. There is still another thing that we need for making a fire. If you will think a minute, you will see what else is needed.

You remember that Mr. Bates piled the twigs for his fire in the shape of a wigwam so that air could get to them. When he was building the fire in the furnace, he opened the draft and shook the grate to let the ashes out. The air could then get into the firebox. To start a fire, there must be air near the combustible materials.

Now you know what we need to make a fire. So you can understand why we light fires the way we do. People had no matches until about 100 years ago. Indians started fires by whirling a hard, pointed stick against a soft piece of wood. As the stick rubbed on the wood, the friction produced heat. Materials with a very low kindling temperature, such as dry wood, leaves, or moss, were put around the rubbing surfaces. When they became hot enough, they burst into flames. You may think it would take a long time to start a fire in this way, but it has been done in about six seconds! The boy in the picture is making a fire in this way.

Another way of starting a fire by friction was used a long time ago. A piece of flint and a piece of steel were struck together to make sparks. The sparks fell on bits of dry, decayed wood or scorched linen, called *tinder.* Tinder catches fire easily. Even today we use friction to start fires. In friction gas lighters and cigar lighters, a steel wheel turns against a piece of flint to make sparks. The sparks fall on a wick soaked in a liquid that catches fire easily.

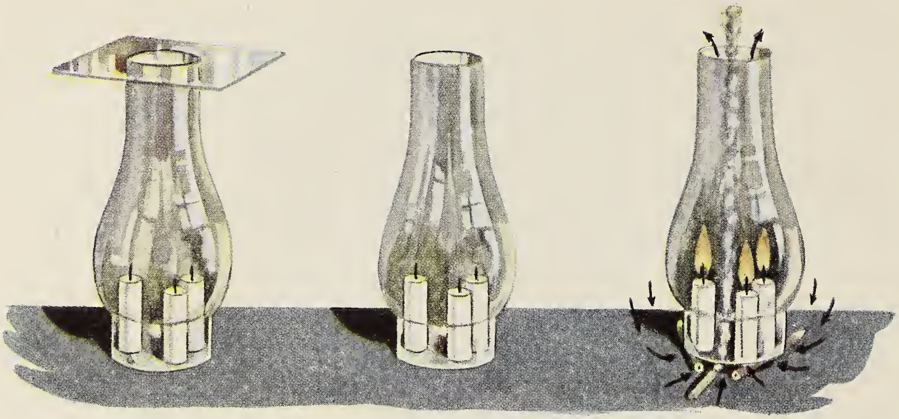
Matches that would light when their tips were rubbed on something were invented only about 100 years ago. The tips are made of materials that can be set on fire easily. Rubbing them on a rough surface makes the tips hot enough to burst into flames. Matches have been greatly improved since they were first invented. Safety matches will not light when they are rubbed on just any rough surface. They must be struck on a specially prepared surface. They are less likely to be lit by accident. Some matches are made so that the tips will not fly off when they are struck, and the matchsticks will not glow after the flame is out. Matches help us, but they must be used very carefully.

Safety rules for using matches

1. Never leave matches where rats or mice can get at them. Rats or mice have started fires by chewing on matches.
2. Never carry loose matches in your pocket. If the matches are in a cardboard folder, keep the folder closed.
3. Before lighting a match from a folder, close the folder. Sparks from the match may set the other matches on fire.
4. Be sure that the match is completely burned out and is cold before you throw it away.

---

1. *What is a* combustible *material? Name some materials that are combustible.*
2. *Why do we use matches to light a fire?*
3. *What does* kindling temperature *mean?*
4. *Which of these materials have a low kindling temperature?*
   Paper Gasoline Hard coal Leaves Large stick of wood Wood shavings Cloth
5. *What are the different ways that have been used to start fires? Which way is easiest?*



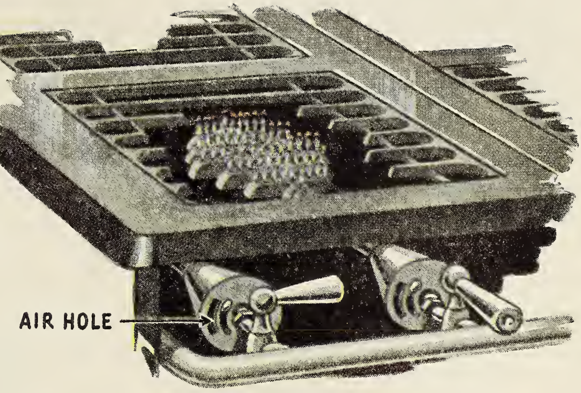
What do fires need to keep them burning?

To answer this question, let us first do an experiment. Get three small candles, each about two inches high. Set them on a piece of glass and light them. Put a lamp chimney over them and cover the top of the chimney with another piece of glass. What happens? Do you think the candles will burn if you leave the top of the chimney open? Light the candles again and set the chimney over them without the glass. What happens this time?

Now put a few short pencils or other sticks around the candles. Light the candles again and set the chimney on the pencils. As you can see, the candles keep on burning. Light a splinter of wood or a small roll of paper. Let it burn for a moment and then blow out the flame. Hold the smoking splinter at the bottom of the chimney. Where does the smoke go? Now let us see what the experiment showed.

The candles kept on burning only when air could get in at the bottom of the chimney and out at the top. This means that a current of fresh air must be kept moving past the flames.

You know how this current of air is made. The burning candles heat the air in the chimney. When air is heated, it expands and gets lighter. The air outside the chimney is colder than the air inside. This colder air is heavier than the hotter air inside. Gravity pulls down on the colder air with more force. This heavier, colder air goes under the chimney and pushes the lighter, hotter air up. The same thing happens with a fire outdoors or in a furnace or stove.



Look at the pictures on this page. The picture on the left shows how fresh air gets into a kerosene lamp. The air gets to the flame through the holes below the chimney.

The other picture shows how a burner in a gas stove is supplied with gas and air. Gas comes into the burner through the pipe along the front of the stove. Air enters through the air holes and mixes with the gas. So when the gas is lighted, it has oxygen to keep it burning. Now let us see what we need to start a fire and keep it going.

1. We need a combustible material.
2. We need to heat the combustible material to its kindling temperature.
3. We need a material with a low kindling temperature to start a fire easily.
4. We need to arrange the fire so that it can get a current of fresh air.

---

1. *What things are needed to make a fire?*
2. *Tell how you would arrange materials to make a fire. Give reasons for what you would do.*
3. *Why must ashes be taken out of a furnace or stove?*
4. *Does a fire help keep itself burning? Explain your answer.*
5. *A pile of wood shavings burns more easily than a pile of sawdust. Explain why this is true.*
6. *Why is it hard to burn a thick magazine? What is the best way to do this?*

What happens when things burn?

WITHOUT FIRE, our lives would be very different and much less comfortable. We use fire to keep our homes and other buildings warm, to cook our food, and to supply hot water for washing. Fire changes water to steam that can make our machines move. And it burns gasoline in a gasoline engine or oil in a Diesel engine. Fire helps use the energy stored in materials to do our work, to keep us warm, and even to give us light.

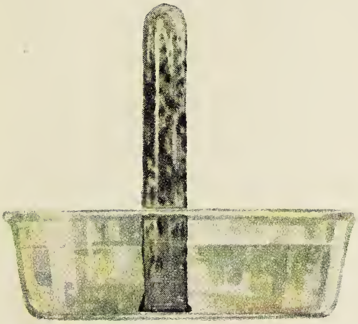
As you know, any material that we burn to get heat or light is called a fuel. We have solid fuels, such as wood, coal, and coke. Coke is made by heating coal. We have liquid fuels, such as oil, gasoline, kerosene, and alcohol. And there are several kinds of gas fuels. Your home is heated with wood, coal, coke, oil, or gas. In the kitchen, your mother probably uses gas, kerosene, gasoline, coal, or wood to cook your meals. If you live in the country, you may use kerosene lamps or gasoline lamps to give you light. In some ways, all fuels burn alike. So let us find out what happens when any kind of fuel burns.

When anything burns, it gives off something you can feel. If you have ever put your hand near a fire, you know what it is. It is heat. Every fire gives off heat. No matter what kind of fuel is used, it gives off heat when it burns. And it usually gives off something you can see, too. A flame gives off light. Wood, coal, oil, gas, kerosene, and gasoline all burn with a flame. But the color of the flame is not the same for every fuel. Coke does not burn with a flame like most fuels, but it does glow and give off light.

You must have noticed something else when a thing burns. It gets smaller and smaller. Liquid fuels, such as oil, kerosene, or gasoline, and gas fuels disappear completely when they burn. Solid fuels, such as wood and coal, always contain some materials that will not burn. These materials are left as ashes.

Sometimes, but not always, smoke is given off when a thing burns. This happens when there is not enough fresh air. Unless a fuel gets plenty of air, it cannot burn freely. Smoke shows that part of the fuel is not being completely burned. For smoke is mostly tiny bits of fuel that are carried up by currents of air from the fire.

Besides the things you can feel and see, other things are happening when a fuel burns. Scientists know what these things are, and they can explain them. You already know that a chemical change takes place when any material burns. After a piece of hard, black coal burns, only a few gray



ashes are left. You can easily see that a chemical change has taken place, because ashes are very different from coal.

The experiment showed that a current of fresh air is needed to keep a material burning. As you probably know, air is not just one gas. It is a mixture of gases. About four fifths of the air is nitrogen, and one fifth is oxygen. It also contains carbon dioxide, water vapor, and a very small amount of a few other gases.

Perhaps you have wondered if all the parts of the air are used in burning or just one part of it. Does a burning material need nitrogen to keep it burning? Or does it need oxygen or some other gas in the air?

One way to find out is to take the oxygen out of some air and then see if materials will burn in the air after the oxygen has been taken out. There are several different ways of doing this. One of the easiest ways of taking oxygen out of the air is to let iron rust in the air. You remember that when iron rusts, it changes to a soft, crumbly material because it combines with oxygen. A chemical change takes place. From the iron and the oxygen, a new material is made.

Fill a test tube or a small bottle with water and then pour the water out. The inside of the test tube will stay wet with water that sticks to it. Now put some iron filings into the test tube and shake it. The filings will stick to the wet sides of the tube. Set the test tube with its mouth down in a pan of water and leave it there for several days. Look at the test

tube from time to time but do not take it out of the water.

The dark-gray filings change to a brownish color as they rust. This shows you that the iron has rusted. When iron rusts, it takes oxygen from the air. If you look carefully, you can see that water rises in the test tube and takes the place of the oxygen. After a few days, all the oxygen in the test tube has combined with the iron filings. You can use the test tube to find out if materials will burn in air that has no oxygen in it.

Put your thumb over the mouth of the tube under water. Take the tube out and turn it right side up. Keep your thumb over the mouth. Now light a match. Then quickly take your thumb off the test tube and put the burning match down into it. What happens? This experiment and others all show the same thing. No material will burn unless there is oxygen to combine with it. All materials combine with oxygen when they burn.

Now do an experiment to see what happens when a paraffin candle burns. Paraffin is a compound made of two elements, carbon and hydrogen. Light the wick of the candle. After the candle is burning well, blow it out. Notice the white smoke that is given off for a short time afterward. Light the candle again and then blow it out when it is burning well. Hold a burning match in the white smoke about half an inch above the top of the wick. What happens?

As the candle burns, the paraffin changes to a liquid. Most of this liquid gets hot enough to change to a gas, but some of it does not. You can see this liquid running down the sides of the candle. After the candle is blown out, the white smoke contains tiny bits of paraffin. If you hold a burning match close to the wick, the paraffin in the smoke will burn and light the candle again.

The gas contains the same two elements as paraffin. They are carbon and hydrogen. You can see that the gas contains carbon if you hold a cold plate in the candle flame. This cools the carbon so that it does not burn. You can see the black, unburned carbon on the plate.

When carbon burns, it joins with oxygen to form a compound called carbon dioxide. You have already heard of carbon dioxide. It is a colorless gas. When you breathe out, it is given off from your lungs. You can do an experiment to find out if carbon dioxide is formed when a candle burns.

You will need some *limewater* for the experiment. Limewater is a clear liquid that turns milky when carbon dioxide is put into it. Pour some clear limewater into a glass. Use a piece of glass tubing or a soda straw to blow air into it for about two minutes. Does the limewater turn milky? Then there is carbon dioxide in the air you breathe out.

Now fasten a piece of wire around the candle and light it. Then lower it into a glass jar. Cover the jar with a flat piece of glass. When the candle goes out, slide the cover a little to one side and pull the candle out. Then quickly pour some clear limewater into the jar. Cover the jar and shake it. What happens to the limewater? What makes it do this?

Carbon dioxide was formed in the jar when the candle burned. Carbon in the gas combined with oxygen in the air. Of course, there was a little bit of carbon dioxide in the jar before the candle burned. Air contains some carbon dioxide. But there was much more carbon dioxide after the candle burned. You can easily see this for yourself. Pour some clear limewater into another jar and shake it. Look at the limewater in this jar and in the other jar where the candle burned. What difference do you notice? Which jar has more carbon dioxide in it?

Now you can do another experiment to find out what happens to the hydrogen when the candle burns. Light the candle and put the mouth of a cold glass jar down over it. Be sure that the glass jar is thoroughly dry. Hold it so that the burning candle can get air. Now look at the inside of the jar. Do you see moisture sticking to the sides? This moisture is water. When hydrogen combines with oxygen, water is formed. Water, as you know, is a compound made of hydrogen and oxygen.

From what you have learned about a burning candle, you can understand why it disappears as it burns. The carbon in the paraffin combines with oxygen to form carbon dioxide. As you know, carbon dioxide is a colorless gas. It quickly mixes with the air. The hydrogen in the paraffin combines with oxygen to form water. The water is in the form of water vapor, which is also colorless. And it also mixes with the air. A burning candle disappears because it joins with oxygen to form colorless gases.

Nearly all the fuels we use contain hydrogen and carbon. When these fuels burn, they first change into a gas that contains carbon and hydrogen just as the candle did. Then this gas burns and forms carbon dioxide and water vapor. As these fuels burn, they get smaller or disappear completely. The materials that do not combine with oxygen are left as ashes.

1. *How can you tell when a material is burning?*
2. *Tell what you did to show that a material must have oxygen when it burns.*
3. *How did you tell that carbon changes to carbon dioxide when it burns?*
4. *How did you tell that hydrogen changes to water vapor when it burns?*
5. *Why do some fuels disappear completely when they burn? Name some fuels that do this.*
6. *What are ashes? Name some fuels that leave ashes when they burn.*

How can we conserve our fuels?

DID YOU EVER see black smoke pouring out of a chimney? The smoke is mostly tiny bits of unburned carbon. In a big city where many homes, factories, and railroads burn fuel, smoke is often a nuisance. The air is full of smoke. People breathe it into their lungs, and it is bad for them.

Tiny bits of carbon settle as greasy, black soot on clothing, furniture, buildings, and streets. Then people must spend much time and money to get things clean again. On a calm day, smoke sometimes gathers in a thick cloud over the city. It cuts off much of the sunlight. Electric lights must be turned on. That uses more of our fuel, too.

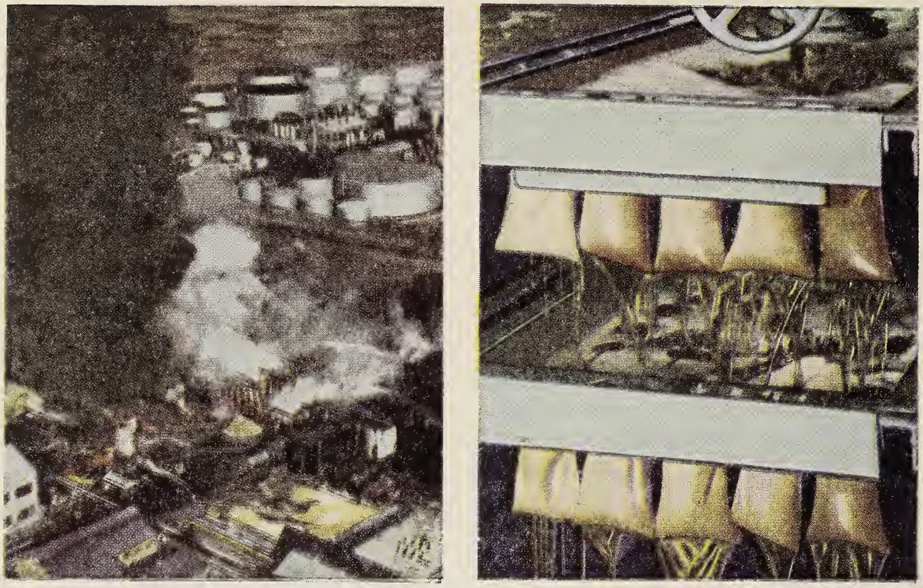
But smoke is more than a nuisance. It is a waste of valuable fuel. We get no heat from fuel that goes up in smoke. So we have to use more fuel to get the heat we need. Whenever you see black smoke coming out of a chimney, you can tell that fuel is being wasted. Do you know why fuel is so valuable that we must not waste it? Of course, fuel costs money. When we buy fuel, we want heat and not smoke. Yet there is another important reason why we must save fuel.

Our common fuels are wood, coal, coke, oil, gasoline, kerosene, and gas. As you know, coke is made by heating coal. Gasoline and kerosene come from oil. We get gas from the earth and also from coal and oil. Every year we use more and more fuel. But in all the world only one of our common fuels is now being replaced. That is wood. The coal, oil, and gas we take from the earth were made millions of years ago. When they are gone, there will be no more.

Scientists think that our supply of coal will last at least 100 years. Our supplies of oil and gas may not last so long if we keep on using them up as fast as we do now. Just how long our supplies of coal, oil, and gas will really last depends on how carefully we use them. If they are wasted, they will be gone much sooner than if we use them carefully. That is why we must conserve our fuels.

One thing we can do is to keep fires from smoking. There are only two reasons why a fire smokes. Either the fuel does not get enough oxygen, or some of it is not hot enough to catch fire. You have probably seen smoke coming out of the pipe behind an automobile. The smoke shows that not enough air has been mixed with the gasoline or that the mixture is not hot enough to burn completely.

A kerosene lamp or stove will smoke if the wick is turned too high. There is not enough oxygen near the wick to burn the kerosene. If gas or oil burns with a smoky, yellow flame, not enough air is being mixed with the fuel. Tiny bits of hot carbon make the flame yellow. If coal is burned in a furnace or stove, we can open the draft wider to get more oxy-



Lightning started this fire in which thousands of gallons of valuable oil are being wasted. The picture on the right shows how one big company is saving oil. The oil is put through cloth bags to remove the dirt. Then the oil can be used again.

gen to the fire. Or we can take some ashes out of the grate and the ash pit. Air can then get to the coal.

Too much coal should not be put on a fire at one time. Before any fuel will burn, it must be hot enough to catch fire. You saw carbon collect on a cold plate held in a candle flame. The carbon was not hot enough to burn. The same thing happens when too much coal is put on a fire. Some of it does not get hot enough to catch fire. Then unburned carbon and gases go up in smoke. This often happens when a coal fire is started.

We can conserve much coal if we learn to use it properly. To get the most heat and the least smoke from coal, we should put only a little coal on a fire at one time. We will have to put coal on more often, but most of it will burn. Very little coal will go up the chimney as black smoke, as it is doing in the chimneys in the picture on page 161.

An *automatic stoker* is a machine that makes it easy to conserve coal. This machine supplies just the right amount of coal to a fire all the time. A stoker can be connected to a furnace in a home. Or it can be used with a boiler in a big building, a factory, or a locomotive like the one in the picture on page 60.

Heat will not easily go through some kinds of materials. Putting blocks of material like this inside the roof and walls of a house is one way to keep heat from being wasted.

Another thing we can do to conserve our fuels is to save heat. Much of the heat we get from fuels is wasted. Heat goes out through the roof, walls, and windows of our buildings. There are several ways to cut down this loss of heat. We can fill cracks so that hot air cannot get out and cold air cannot get in. We can put special materials in the walls and roof to keep heat in. And we can use double glass in the windows.

A great deal of heat is wasted in cooking. When an oven door is open, heat is lost. It also goes out through the sides and top of the oven. When a small pan is set over a large burner on a stove, heat is wasted around the sides of the pan. More heat from the burners is lost when food is cooked in uncovered pans. But the biggest loss of heat probably comes from using a hotter fire than is really needed to cook the food.

Scientists have made discoveries that help us conserve our fuels. Better stoves, furnaces, and boilers have been invented to give more heat and use less fuel. Steam engines, gasoline engines, and Diesel engines have been greatly improved. They now make better use of the energy stored in the fuels that we need.

No matter how carefully we use our supplies of coal, oil, and gas, there is still no way to put more of them back in the earth. So we must find other ways to conserve the supplies we now have. One way is to use fuels made from plants whenever we can. Wood is a common fuel where it is cheap and plentiful. Gas and alcohol can be made by heating wood. Alcohol can also be made from grain. But most of these plant fuels cost more to use than coal, oil, or gas that we take from the earth.

Still another way to conserve fuels is to make more use of other sources of energy. Moving water is used to turn machines that produce electric current. In some parts of our country where electric current is cheap, it is already being used to cook food and heat water. Moving air can also be used to produce electric current. But unless the wind is blowing, no electric current is produced.

For many years, scientists have been trying to find ways to use the huge amounts of heat we get from the sun. So far, they have not found a really good way to do this. A few homes have been built so that on clear days the sun helps heat them. Some day scientists may learn how to use the energy stored in all materials. Until they do this, we must conserve the supplies of coal, oil, and gas that are now in the earth.

1. *Why must we conserve our supplies of coal, oil, and gas?*
2. *Give as many ways to conserve fuel as you can. Tell how each way helps save fuel.*
3. *Is fuel being wasted in your community? How do you know?*
4. *If cooking pans become very black on the outside every time they are used on a gas stove, what should be done? Why?*

What can we do to prevent fires?

No one knows when fire was first used or who discovered how to use it. We do know that it was one of the greatest discoveries ever made. When fire is under control, it keeps us warm and helps do our work. But something very different happens when fire gets out of control. Buildings and forests are destroyed. People and animals are burned. Every year, fires do great damage.

Almost all of these fires are accidents. But accidents do not just happen. They are caused by people who

This forest ranger cleared the grass away before he built his fire. Now he is putting the fire out before he leaves. What two things will he do to make sure that the fire is out?

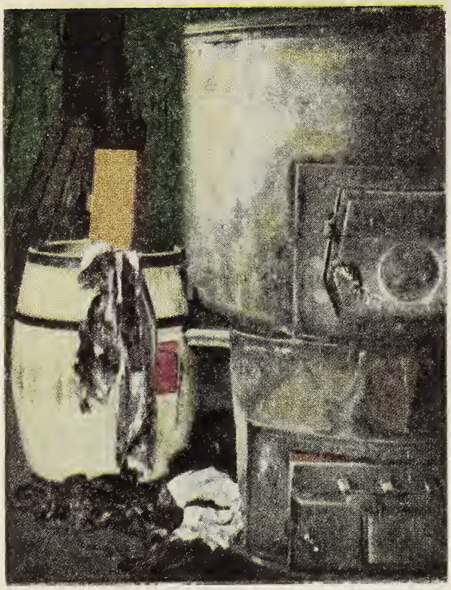
are careless. Once a fire gets started, it is often hard to put out. So the best way to keep fires from doing damage is to keep them from starting at all.

To start burning, every fire must have three things—a combustible material, enough heat to raise the material to its kindling temperature, and a supply of oxygen. If any one of these three things is missing, a fire cannot start. To prevent fires, we can use what we know about starting fires.

In our homes and other buildings, *fireproof* materials can be used in many places. The materials that will burn should not be put near heat that might set them on fire. Liquids or gases that catch fire very easily should be put into airtight, fireproof containers and kept away from heat.

We can prevent many fires by being careful with matches. People light matches and throw them away before they are out. If they fall on something that will burn, a bad fire may start. Matches should always be kept in a safe place where they cannot start a fire by accident. They should never be left where little children can play with them.

You already know why we must be careful with fires outdoors. An open fire can easily spread to other things if it is not made properly. Leaves, grass, and twigs should be cleared away from the ground where the fire



Do you think this a safe place to keep old rags? Why?

is made. The fire must be kept away from trees, bushes, or anything else that may spread it.

A small fire is safer than a big one. If a fire is too big, it makes a strong current of air move toward the flames and then upward. This current of air may carry sparks and other bits of burning material to grass, trees, or buildings nearby. The same thing can happen on a windy day with even a small fire.

Many parks have fireplaces where you can cook your meals. It is safest to use one of these fireplaces if you want to cook outdoors. But any outdoor fire should be watched all the time. Be sure to put it out with water, sand, or dirt before leaving it.

Sometimes people start fires with kerosene or gasoline. This is a very dangerous thing to do. Only a little heat will set kerosene and gasoline on fire, because they quickly change from a liquid to a gas. If much of this gas catches fire at one time, it may explode. The explosion will scatter burning materials from the fire. This is bad enough with an outdoor fire, but it is far worse with a fire that is being made indoors. Never use kerosene or gasoline to start a fire.

Fires are sometimes started by oily rags that have been wadded up or thrown in a pile. What happens is this. Oxygen slowly combines with the oil. A little heat is produced. The rags get warm. Because the rags are in a wad or pile, all the heat cannot get out. The rags get warmer and warmer. At last, some of the oil changes to a gas. The rags are hot enough to set the gas on fire. It bursts into flames and sets the rags on fire, too. Oily rags should be spread out, hung on a line, or kept in a covered metal container.

There are many ways in which fires can start. Kerosene or gasoline lamps fall on the floor or set fire to curtains. Wooden boxes catch fire when hot ashes are put in them. Electric wiring gets hot enough to start something burning. Hot cooking fats blaze up on a stove. Liquids used for cleaning, such as naphtha and gasoline, catch fire from friction. But no matter how the fire starts, the real cause is usually this. Someone was careless.

Safety rules for preventing fires

1. Be careful with matches. Put them out before you throw them away. Use safety matches if possible. Keep large kitchen matches in a covered metal box.
2. Keep an outdoor fire from spreading. Build a small fire. Make it on bare ground in a place where the wind will not blow it toward anything that may catch fire.
3. Before you leave an outdoor fire, put it out. Pour water on it or cover it with sand or dirt.
4. Never use kerosene or gasoline to help start a fire. Use paper and small bits of wood.
5. Do not set kerosene lamps or gasoline lamps where they can fall on the floor or set fire to curtains. Put them near the center of a table and away from windows.
6. Do not leave oily rags wadded up or thrown in a pile. Spread them out, hang them up on a line, or keep them in a covered metal container.
7. Put ashes in metal containers instead of wooden boxes.
8. Do not use worn or broken electric cords.
9. Replace a "blown" electric fuse with another of the right size.
10. Do not play with firecrackers or any kind of fireworks.
11. Be careful about using flour and cornstarch over an open flame, such as on a gas stove. They may start a fire or explode.
12. Be careful with hot cooking fats on a stove. They easily blaze up and spread fire.
13. Do not use naphtha or gasoline to clean clothes indoors. It is dangerous even to use them outdoors.

---

1. *What is the best way to keep fires from doing damage?*
2. *Tell how you can use what you know about burning to prevent fires.*
3. *Give a reason for each of the first six safety rules for preventing fires.*
4. *What is usually the cause of a harmful fire? Explain your answer.*
5. *Have there been any fires that caused much damage in your community? How did they start?*

How can we put out fires?

WHAT SHOULD YOU DO if you see a fire start? The first thing to do is tell a grown-up. If you cannot find one, report the fire at once to the fire department. You should know what telephone number to call. Find out if you do not know. Even if you do not know what number to call, you can ask the telephone operator to report the fire. But this usually takes more time. And the sooner the fire is reported, the quicker the fire department can get there to put it out.

If you live in a city, you will probably find a fire-alarm box every few blocks. There are different kinds of fire-alarm boxes. One kind is kept locked, and the key is at the nearest house or store. In another kind, you open a small door on the front of the box, pull a lever down all the way, and then let it go. Still another kind has a glass door you must break to pull the lever. When the lever is pulled, a signal sounds in the central fire station. Then an alarm is sent to the fire station that is nearest the fire-alarm box.

Always stay near the box until the fire engine arrives, so that you can tell the firemen exactly where the fire is. If you ever have to report a fire, you will be in a hurry. So be sure to find out ahead of time how to work the fire-alarm boxes in your city. Never report a fire unless there really

This man is cutting a fire lane. If the grass catches fire on one side of the lane, the fire will probably not jump across the bare lane.

is one. If a fire engine comes to answer a false alarm, it may be too late to get to a real fire somewhere else. Then the real fire might get such a big start that many buildings would be burned.

You already know what things a fire needs to burn. So you can probably tell three things we can do to put out a fire. One thing we can do is to clear away from the fire any material that will burn. This will keep the fire from spreading. Another thing we can do is to cool the burning material so that it is no longer hot enough to burn. The third thing we can do is to shut off the supply of oxygen. Let us see how these things are actually done.

In the forest, *fire lanes* are usually made. A fire lane is a wide path from which all trees and bushes have been cut away. Sometimes it is plowed to cover the grass and leaves with soil. A fire lane is one way of clearing away materials that will burn. When a fire starts in the forest, it may keep on burning until it gets to the fire lane. Unless the wind is strong, the fire usually cannot jump across the fire lane.

A grass fire can sometimes be stopped by making a *backfire.* To do this, the grass is set on fire some distance ahead of the main fire. The backfire is kept under control. It makes a wide burned space in the

Can you tell why great clouds of smoke pour out when water is put on a fire?

grass. When the main fire gets to the burned space, it usually stops because there are no materials left to burn.

Sometimes a large fire in a big city gets completely out of control. The fire is so hot that firemen cannot go near it. To keep the fire from spreading, the firemen may blow up buildings in the path of the fire. The buildings fall into a heap, covering up the materials that will burn easily. When the fire gets to them, there is not much left to catch fire. The firemen have removed the material that will burn from the path of the fire.

Of course, the commonest way to put out a fire is to throw water on it. The water does two things to put the fire out. It covers the burning materials and shuts off the supply of oxygen. It also cools the burning materials so that they are no longer hot enough to burn. Small fires are easily put out with water. To put out large fires, like the one shown in the picture on this page, thousands of gallons of water must be used.

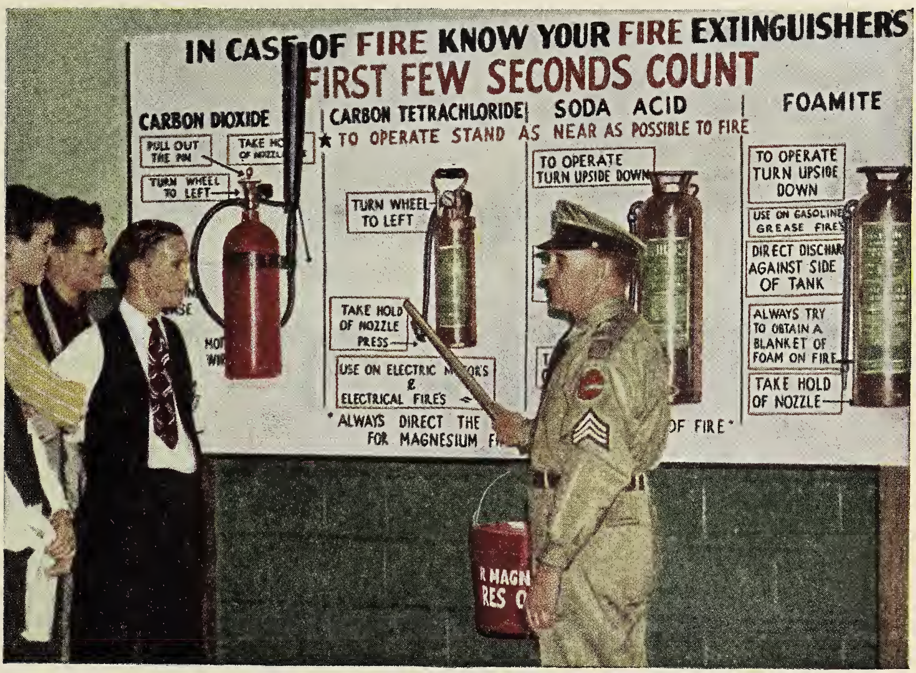
But a stream of water will not put out some kinds of fires. Sometimes hot cooking fats blaze up on a stove. If water is poured on the blazing fat, it will just spread the fire. Do you know why this happens? The cooking fat is lighter than water. So it floats on top of the water. Then the water cannot shut off the supply of oxygen. As the water spreads, the blazing fat spreads, too. Never pour water on blazing fat. Throw baking soda on it or put a metal cover over it.

When kerosene, gasoline, or oil catch fire, they act like blazing fat. A stream of water only makes them spread. They are lighter than water, and they float on top of it. The water does not shut off the supply of oxygen. But firemen sometimes use a fine spray of water to put out a kerosene, gasoline, or oil fire. The fine spray cools the burning materials until they are no longer hot enough to burn. And it does not spread the fire as a stream of water would.

Another way to put out a fire of kerosene, gasoline, or oil is to throw sand or dirt on it. This shuts off the supply of oxygen. It also cools the burning material.

A third way is to use a fire extinguisher that contains *carbon tetrachloride.* This is a liquid that changes to a gas when it gets hot. The gas is about five times as heavy as air. It settles on the fire, covers the burning material, and shuts off the oxygen. Many people carry this kind of fire extinguisher in their automobiles. It can be used on most kinds of fires.

You should know how different kinds of fire extinguishers work. Can you tell why this is true?


IN CASE OF FIRE KNOW YOUR FIRE EXTINGUISHERS
FIRST FEW SECONDS COUNT
CARBON DIOXIDE
PULL OUT THE PIN
TURN WHEEL TO LEFT
CARBON TETRACHLORIDE
★ TO OPERATE STAND AS NEAR AS POSSIBLE TO FIRE
TURN WHEEL TO LEFT
TAKE HOLD OF NOZZLE PRESS
USE ON ELECTRIC ELECTRICAL FIRES
*ALWAYS DIRECT THE
FOR MAGNESIUM
SODA ACID
TO OPERATE TURN UPSIDE DOWN
OF FIRE*
FOAMITE
TO OPERATE TURN UPSIDE DOWN
USE ON GASOLINE GREASE FIRES
AGAINST SIDE OF TANK
ALWAYS TRY TO OBTAIN A BLANKET OF FOAM ON FIRE
TAKE HOLD OF NOZZLE

In your school, there is probably another kind of fire extinguisher. It makes carbon-dioxide gas. You can do a simple experiment to see how carbon-dioxide gas puts out a fire. Put a teaspoonful of baking soda in a glass and pour some vinegar on it. Then hold a lighted match in the glass. What happens? A chemical change made carbon-dioxide gas from the baking soda and vinegar. The carbon-dioxide gas shut off the supply of oxygen from the lighted match, and the match could no longer burn.

When a carbon-dioxide fire extinguisher is turned upside down, an acid mixes with another material dissolved in water. A chemical change takes place, and carbon-dioxide gas is formed. The gas rushes out of the extinguisher and forces the water out, too. Carbon dioxide is heavier than air. It settles on the fire and helps shut off the oxygen. The water also helps shut off the oxygen, and it cools the burning material. Because of the stream of water, this kind of fire extinguisher cannot be used to put out blazing kerosene, gasoline, grease, or oil.

The picture on this page shows a special kind of fire truck that is often used to put out very hot gasoline fires. The truck carries carbon-dioxide gas that is kept at a very low temperature. When the carbon dioxide comes out of the truck, it is like snow. It is cold and heavy, and it rapidly cools the burning gasoline below its kindling temperature. At the same time, another material that smothers the fire comes from the truck. This material and the carbon-dioxide snow together can put out a big gasoline fire in less than a minute!

Do you know what to do if your clothes catch fire? The worst thing to do is to run. This fans the flames. It brings more oxygen to the burning clothes and makes them burn even faster. If your clothes catch fire, stand still. Look around for a coat, blanket, rug, or anything like it. Lie down on this covering and roll yourself up in it as tightly as you can. This will shut off the supply of oxygen.

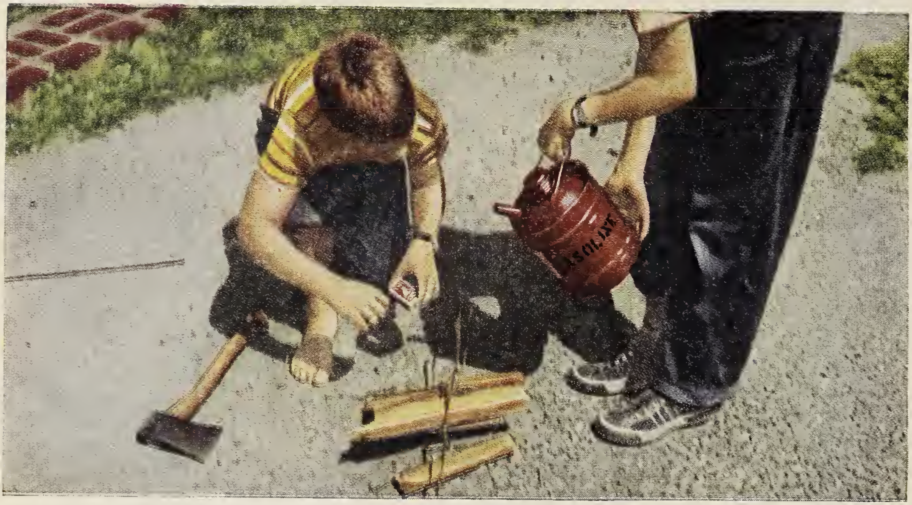
If another person's clothes catch fire, wrap a covering tightly around him. If you can find nothing to wrap around burning clothes, the best thing to do is to lie down and roll over slowly. At the same time, beat out the flames with your hands.

Safety rules for putting out fires

1. If you see a fire start, tell a grown-up or report it to the fire department at once.
2. Find out what telephone number you should call to report a fire.
3. Find out where the nearest fire-alarm box is and how it works.
4. After you report a fire from a fire-alarm box, stay near the box until the fire engine comes. Then tell the firemen exactly where the fire is.
5. Never report a fire unless there really is one.
6. Use water, sand, or dirt to put out small fires.
7. Never pour water on blazing fat. Throw baking soda on it or put a metal cover over it.
8. Never use a stream of water to put out a fire of kerosene, gasoline, or oil. Use sand, dirt, or a fine spray of water.
9. Learn how the fire extinguishers in your school work.
10. If your clothes catch fire, do not run. Lie down and roll up tightly in some covering. Or roll over slowly and beat out the flames with your hands. If another person's clothes catch fire, wrap a covering tightly around him.

---

1. *What three things can we do to put out a fire?*
2. *How does water put out a fire?*
3. *Why should a stream of water not be used on some kinds of fires? Tell how we can put out these fires.*
4. *What should you do if your clothes catch fire?*
5. *Tell what you would do if a fire started in your home.*



Are these boys acting safely? What safety rules should they remember?

QUESTIONS TO ANSWER

1. Why should the wood in a fire be loosely piled to burn well?

2. When a fire is started in a furnace or stove, what should be done to the draft and the damper? Explain your answer.

3. If a kerosene lamp smokes, what can you do to make it stop smoking? Tell why this will do it.

4. Explain why there are no ashes from a gas stove or a kerosene stove.

5. A piece of paper burns faster when it is held in the air than when it lies flat on the ground. Why does this happen?

6. Why does a pile of burning leaves give off much smoke when more leaves are thrown on the fire?

7. Kerosene or gasoline should never be put in a lamp that is hot. Explain why.

8. One kind of fire extinguisher makes a sticky foam. How do you think this helps put out a fire?

9. Give a reason for each of the ten safety rules for putting out fires that are given on page 173.

10. How could you do an experiment to discover whether soft coal has a lower kindling temperature than hard coal?

11. How should the draft and the damper on a furnace be arranged to get a hot fire?

12. What can you do to help conserve our supplies of coal, oil, gas, and wood? Explain your answer.

13. Why do you think we have chimneys in our homes?

14. If a fire started where there were no extinguishers, what are the things you might do?

THINGS TO DO

1. Make a drawing of a furnace or stove. Explain how the supply of oxygen is controlled.

2. Visit a fire station near your home or school. Find out what kinds of fire extinguishers the firemen use.

3. Cut out newspaper stories about fires and make a collection. List the different causes of fires reported in the newspapers.

4. Find out what kinds of roofing materials will not burn. Why are they better than wooden shingles?

5. With your teacher watching you, light different kinds of matches to see how they start burning and how they keep on burning.

6. Find out what kinds of fuels are used in your community and what is being done to conserve them.

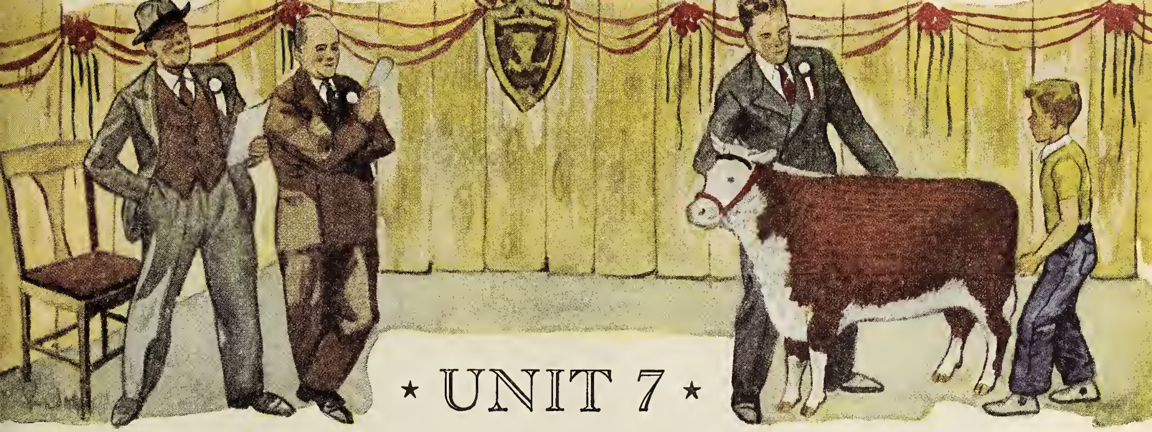
7. What can you and the other members of your class do to prevent fires in your community? Perhaps your teacher can get a fireman to talk to your class about preventing fires.

8. Look around your home for things that may start a fire or spread the fire after it has started. Make a list of the things you find and tell what you can do about them.

9. Find out how fires are sometimes started by *spontaneous combustion.* What kinds of materials may catch fire in this way?

★ *In Unit Seven You Will Learn* ★

★ What food does for you ★ What foods keep you warm and give you energy ★
★ What foods help you grow and keep healthy ★
★ How vitamins help you keep well ★ What water does for your body ★
★ What habits help you get the proper foods ★ What cooking does for your food ★



★ UNIT 7 ★

Why Do You Need Food?

BILL WAS VERY EXCITED when he came to school one morning in the spring. "My father gave me a sheep to raise all by myself," he told his friends. "I'm going to try to win a prize with it in the 4-H Club show at the county fair next fall."

Bill's school was in the country, and many of the children belonged to the 4-H Club. Several of them were raising animals for the show. Bob had a calf. Jim had a pig. Mary had a colt. And some of the others had chickens. They all started to talk about what they had to do to get their animals ready for the show.

"What do you think is the most important thing you do for your animals?" the teacher asked the class.

Almost everyone answered, "Feed them so that they will grow big."

"They must grow strong, too," said Jim. "Animals that weigh a lot need strong bones to hold them up."

"Sheep must be fed so that they will have good wool," said Bill.

"Horses must have food to make them strong enough to pull big loads. The right kind of food makes them strong and also makes their coats smooth and shiny," Mary said.

"Chickens must be fed so that they will lay a lot of eggs," Nancy said.

"All of you are right," said the teacher. "You feed your animals so that they will grow big. But you also feed them so that they will be strong and grow in some other ways, too. The 4-H Club gives you directions that tell you what kind of food to give the different animals so that they will grow the way you want them to. If you follow these directions carefully, you will have healthy animals even though some of you do not win prizes.

"Perhaps there will be a prize for the healthiest boy and girl at the county fair, too. Do you know what to do to be as healthy as possible? Eating the right foods is the most important thing for you to do, too. In this unit, you will learn why."

What does food do for you?

HAVE YOU EVER stood up against the wall so that your father or mother could measure how tall you were? Probably a mark was made on the wall level with the top of your head. A few months later, you were measured again to see how much you had grown. Perhaps you are measured and weighed at school in the fall and in the spring, or even every month. Your parents and teachers want to see how much you are growing.

Growing taller and weighing more are two signs that you are healthy. You should be growing some all the time. If you are not growing much, your mother probably tries to get you to eat better meals. She knows that food makes you grow bigger.

But just because you may not grow so big or so tall as some of the others in your class does not mean that you are not healthy. Other things besides growing bigger show that you are healthy. Here are two stories to help you see that food does other things for you besides making you grow.

One day, a famous woman scientist received a letter. The man who wrote the letter said, "Please tell me how to grow a new set of teeth. I need them." Of course, the scientist could not tell this man how to grow a new set of teeth. But she could tell him how he might have kept his teeth healthy so that he would not need new ones. This scientist had been working for many years to show people that eating the right kind of food will help them to keep their teeth strong and healthy.

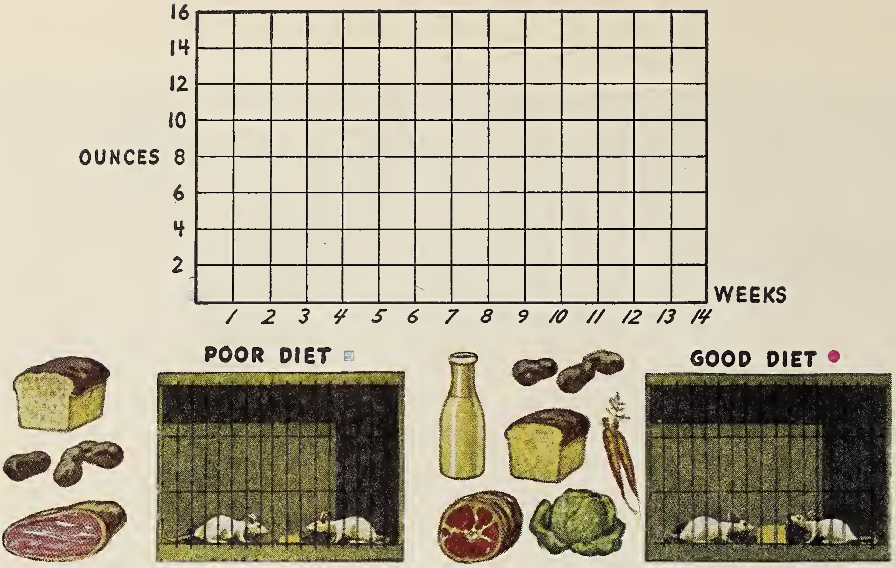
In some parts of our country, not long ago, many people were suffering from a serious disease. The doctors could not find out what caused the disease, and they could not find out how to cure it. Our government sent a doctor to see if he could find out what caused the disease. He studied everything that might help him find out what was wrong. He studied the food that people ate. He thought that perhaps food had something to do with the disease. He did some experiments and found that he was right. People who ate certain foods did not get the disease. People who did not eat these foods got sick.

These two stories show you that food does other things for you besides making you grow bigger. The proper food helps you grow strong, healthy teeth that will last you all your life. It can help you grow a healthy body as well as a bigger one. Some kinds of food make your bones grow strong and straight. Some kinds give you a good, clear skin. Some foods protect you from certain diseases. When your body is very healthy, it can fight disease better. You may not catch so many colds if your body has had enough of the proper kinds of foods.

You probably play and work all day without ever thinking about what makes your body go. But your body could not do all the things it does without energy to make it go. You remember that some foods are energy-giving foods. They give you the strength to do work. Even at night when you are asleep, your body is working. Your heart is pumping blood to every part of your body. Your lungs are breathing. Your food is being digested. And your body stays warm all the time. The energy that keeps your body going and the heat that keeps you warm come from the energy-giving foods you eat.

All the time you are working and playing, you are using up some parts of your body. You need food to make new blood and new skin and some of the materials that keep your body running properly. You get these materials from the foods you eat.

You can see that your food must do many things for your body. You know that your body cannot get everything it needs from just any kind of food. The boys and girls who are raising animals for the 4-H Club know this, too. They know that *what* they feed the animals is just as important as *how much* they feed them. Perhaps your class can do an experiment that will help you find out what kinds of food you should eat. It will help you if you can watch the experiment while you are studying this unit.



Put the weight of each rat on a chart on the day you start your experiment.

Try to get some white rats that are the same age and about the same size. Divide the rats into two groups. Weigh them all and write down their weights. Feed one group lean meat, bread, and potato and give them plenty of water. Feed the other group the same things but also give them some raw and cooked vegetables and milk as well as water to drink. Give both groups fresh food and water every day and keep their cages clean. Weigh them once a week. Make a chart like the one on this page. Put the weight of the rats on the chart each time you weigh them.

Watch them carefully as they grow. It may be several weeks before you notice much difference between the two groups. Which ones grow the more? Which ones look healthier? Why do you think they look healthier? What you learn in the rest of this unit will help you answer this last question.

To see if you are eating the foods that will help you grow best, keep a list of the foods you eat at breakfast, lunch, and dinner. Put down everything you eat between meals, too. You will use this food list as you study the rest of this unit.

---

1. *Name some things that food does for you.*
2. *How does food help you while you sleep?*
3. *What do you expect your experiments with rats to show?*

People who do such hard work as this need foods that give them plenty of energy.

What foods keep you warm and give you energy?

"It's cold this morning," said John's mother when he came down to breakfast. "You'd better eat a big dish of cereal, some buttered toast, and some bacon. They will help keep you warm."

Do you know why the cold weather made John's mother want him to eat these foods? You probably know that the temperature of your body stays about the same all the time. Even when you go out in cold weather, your body still keeps warm on the inside. This means, of course, that there must be some way of producing heat inside your body. You know, too, that you can move your body and other things. This also takes energy.

The heat that keeps your body warm comes from the food you eat. You have seen that heat is produced when fuels combine with oxygen and burn. A chemical change somewhat like this goes on in your body. Of course, there are no flames in your body as there are in a stove. But foods combine with oxygen in your body. When this happens, heat is produced. Scientists can show that this takes place. They even know just how much heat can be produced from a certain amount of food.

SALAD
Oil
A food that gives you Staying Power
Creamery
Butter
Bacon

These foods contain large amounts of fat. Fat gives more energy than any other food.

Heat, as you know, is a form of energy. Your body also needs energy for the muscles to do their work. Many different things are going on in your body even when you are resting. Your heart must keep on beating and you must also breathe. Your muscles need energy even when you are quiet. And much more energy is needed when you play or work. The food you eat must produce this extra energy that you need.

Experiments have shown that certain kinds of foods contain materials that make them better than other foods for providing energy. These food materials are called *fats* and *carbohydrates.* They are called fuel foods or energy foods because they supply us with heat to keep us warm and energy to move our muscles. John's mother knew that cereal, buttered toast, and bacon contain a lot of carbohydrates and fats. So she had him eat these foods for breakfast. She wanted him to have the fuel he would need during the day. Because you need fuel each day, you must know which foods contain fats and carbohydrates. Then you will know what foods to eat to supply you with energy.

Have you ever watched your mother unwrap some bacon that was wrapped in paper? If you have, you probably noticed large grease spots on the paper. You can always tell whether food has fat in it by press-

Foods containing carbohydrates give your body warmth and energy, too.

ing some of the food against a piece of paper. If it leaves a greasy mark, the food contains fat. This is a test for fat. Fat is the substance that makes foods greasy or oily. Get some different kinds of foods and give them this test. Which ones have fat in them?

Butter, lard, and margarine are probably the fat foods that you know best. They are almost entirely fat. Meats have fat in them. Some meats have much more fat than others. If you tested the yolk of a hard-boiled egg, cheese, and nuts, you found that they have fat. For they leave a greasy mark on the paper, too.

Olive oil and peanut oil also make a greasy mark. These liquids and other oils in foods are like fats. When we talk about fats in this unit, we mean oils, too.

And now let us see which foods contain carbohydrates. Starch and sugar are carbohydrates. It is easy to tell when you are eating sugar or a food containing sugar. Any food that has a sweet taste contains sugar. Oranges, bananas, grapes, apples, and berries are all foods containing sugar. Your mother makes pies, cookies, cakes, jellies, candy, and preserves. Usually she puts sugar in them to make them sweet. You will probably have no trouble deciding if a food has sugar in it.

You may not know when you are eating starch. You have probably seen starch that is used in cooking

How could you tell whether these foods have starch in them or not?

and also starch that is put in clothes after they are washed. This starch is a fine white powder. But starch does not look like this in your food. Then how can you tell if you are eating starch?

Get two glasses of water. In one glass of water, put a teaspoonful of starch and stir it. Then put a few drops of iodine in each glass. What happens? What color is the liquid in each glass? The one with the starch in it turns purple or black. Because this always happens when iodine is added to starch, scientists use this test to see if foods have starch in them.

Cut a slice of potato and put a few drops of iodine on it. Is there starch in the potato? Test some other foods, such as cereals, bread, and different fruits and vegetables. Also cut open a corn seed and a bean seed and test them. Some foods have more starch in them than others. Seeds, potatoes, bread, and cereals have much starch.

Fats and carbohydrates are compounds. They are made of three elements—carbon, hydrogen, and oxygen. They are made of the same elements, but they do not have the same amounts of each of these elements in them. Fats have less oxygen than carbohydrates. Carbohydrates supply only about half as much energy as the same amounts of fats do. But we eat more foods with carbohydrates in them than fats. So most of our energy comes from carbohydrates.

The amount of fuel foods a person needs depends partly on what he is doing and partly on where he lives. People who are doing very hard work outdoors need more energy than someone who is sitting inside at a desk. You need more energy foods when you skate or play outdoors in winter, or work in your garden in summer than when you just stay inside and play quiet games.

People who live in cold climates can eat more fats than those who live in hot ones. Their bodies need extra fuel to keep them warm. Wherever you live, you need enough fuel foods to supply you with the energy you need to keep warm and move your muscles.

1. *What is a fuel food? Why is it called this?*
2. *How does your body get energy from food?*
3. *What are two uses of the energy you get from food?*
4. *Name some foods that contain fats. Which of them did you eat yesterday and today?*
5. *Name some foods that contain carbohydrates. Which of these did you eat yesterday and today?*

What foods help you grow and keep healthy?

If you were measured at the beginning of school in the fall, you probably found that you had grown taller since last spring. How much did you grow? One of the things that foods do for you is to make you grow. Foods also help your body to repair the parts that wear out as you work and play. Foods make new blood, and they make certain materials that keep your body working well.

Many foods contain a material called *protein.* Protein contains the elements carbon, oxygen, and hydrogen, just as the fats and carbohydrates do. But protein always has one more element, too. It always has nitrogen in it. Sometimes protein contains the elements sulphur and phosphorus.

The lean part of meat is made of protein. Protein is found in milk, too. Cheese is made from milk, and so it gives you protein. Eggs, fish, and a few vegetables like peas, beans, and soybeans have a great deal of protein

Foods like the ones in this picture provide protein for building your body.

in them. You see that there are many kinds of foods that supply protein to our bodies.

Protein is often called the body-building food. It is used to build up your muscles and other parts of your body. If you fall down and skin your knee, protein helps make new skin. Your body can and does use protein to give you energy, but protein is used mostly as a building material. Right now you are growing fast and need to give your body plenty of body-building foods.

But protein is not the only material in food that you need to grow and keep your body healthy. Your mother probably gives you a glass of milk to drink with your meals. Milk is one of our very best foods. It contains fat, sugar, and protein. It contains two elements that your body needs to make bones and teeth. One of these elements is calcium, and the other is phosphorus. The hard parts of your bones and teeth are made of calcium phosphate. This is a compound of calcium and phosphorus combined with oxygen.

Calcium and phosphorus are called *minerals*. Without these minerals, your bones would not be strong enough to hold you up or to protect the soft parts inside your body. And you could not bite into foods and chew them with your teeth. Much of your food would have to be chopped up before you could eat it.

If you eat plenty of these kinds of foods, you will be getting the minerals you need.

If you can get a slender chicken bone, you can do an experiment that will show you very well what your bones would be like without calcium. Put the bone in a dish and cover it with strong vinegar. Let it stay there for several days. What can you do with the bone when you take it out of the vinegar? Can you bend it enough to tie it in a knot? The acid in the vinegar dissolved the calcium in the bone. There is no longer any calcium in the bone to make it stiff. It has become soft enough to bend.

Your second set of teeth must last for the rest of your life. You can see why it is very important to keep your teeth strong and healthy. Calcium and phosphorus are being used up in your body all the time. You need to keep taking in more to replace what is used up. Milk is the best food to give you calcium. But many vegetables give you a little calcium, too. Milk, egg yolks, cheese, liver, and some vegetables also have phosphorus in them.

Your body needs other minerals besides calcium and phosphorus. Scientists have found that you need about fourteen different minerals to keep your body healthy. You get enough of most of them in your food without worrying about it. But you need to choose your food well to get enough of some of them. You need iron for your blood. Liver, prunes, lean meat, egg yolks, molasses, and potatoes are some of the foods that contain iron.

Another important material your body needs is iodine. Iodine is one of the elements. You get enough iodine if you eat fish, oysters, clams, and other seafoods. Perhaps you live in a part of the country where it is hard to get seafoods. Then you can use salt that has some iodine in it. It is called "iodized" salt. Look on the package of salt at home and see if you are using the kind of salt that has iodine added to it.

1. *What kinds of foods do you need to build new body material?*
2. *Name some foods that contain fairly large amounts of protein. Which of these have you eaten yesterday and today?*
3. *Why must you eat foods that contain minerals? Name some minerals that you need.*
4. *How are protein foods different from fat foods and carbohydrate foods?*

How do vitamins help you keep well?

MANY YEARS AGO, sailors on long sea voyages used to have a disease called *scurvy*. This is a very painful disease. The mouth becomes sore, and the gums bleed. The joints swell up, too. In those days, people did not know how to keep foods fresh. Sailors could not take fresh fruits or vegetables with them on long voyages. At last, someone discovered that the sailors did not get scurvy if they drank lime juice. After that, ships carried big bottles of lime juice with them. Something in the lime juice prevented scurvy, but no one knew what the something was. The same something is also found in lemon juice, orange juice, and tomato juice.

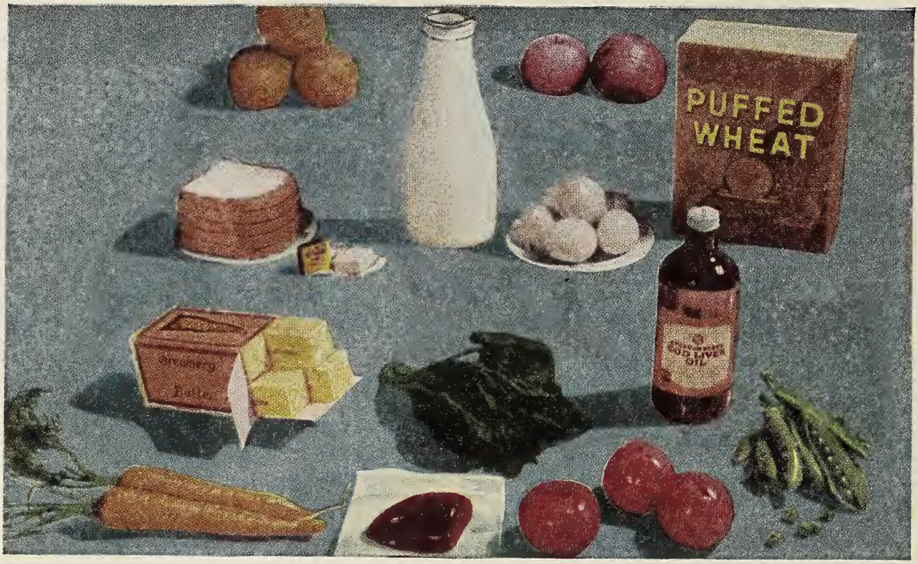
A doctor on an island in the south Pacific Ocean had many people in his hospital who were sick with a disease called *beriberi*. This disease made their legs so weak that they could not stand up. One day, he noticed that some of the chickens in the chicken yard near the hospital were acting very much like the people who had beriberi. Their legs and feet were weak, and they could hardly stand up. Then he noticed that the chickens were being fed white rice. This was what the people in the hospital were eating, too.

The doctor found out that the little boy who was feeding the chickens sometimes bought brown rice. This brown rice was cheaper. Then the doctor noticed something

that set him to thinking. The chickens did not get sick when they ate the brown rice. Could this disease have something to do with what the people and the chickens ate?

This doctor was a good scientist. He did an experiment to try to find the answer to his question. He put some chickens that were not sick in a pen and fed them on white rice. They all got sick. Then he gave them brown rice, and they got well. He knew that white rice is made by grinding off the brown outer layers, or hulls, of the grains of rice. He found that there was something in these brown outer layers that could keep chickens and people from getting beriberi. The doctor had made a great discovery. But it was many years before scientists found out what the material in the rice hulls is.

Perhaps you have guessed by now that the material in the lime juice and the material in the rice hulls are *vitamins.* The word vitamin was made up by scientists as a name for these materials. For a long time, scientists did not even know what the materials were or how many of them there were. They called the first vitamin they discovered *vitamin A.* The next one was called *vitamin B,* and so on. Later, they found that there were several kinds of one vitamin. They have found that vitamin B is at least five or six different vitamins. So they named them *B one,*



You will not need to take vitamin pills if you eat plenty of these kinds of foods.

B two, and so on. They are written like this, vitamin B_1, B_2, etc. Each vitamin helps your body in certain ways. Foods that contain vitamins are often called *protective foods,* because they protect us from certain diseases.

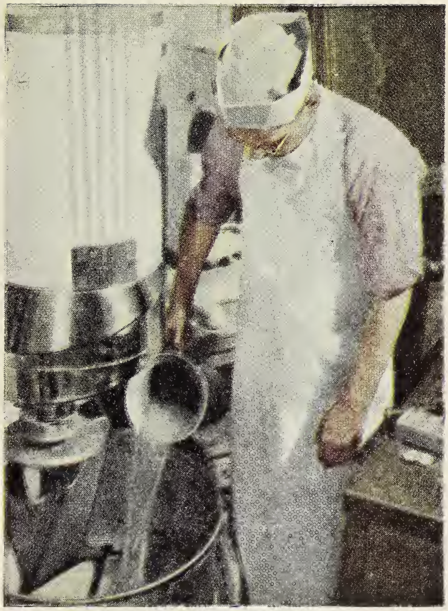
Vitamin A keeps you growing well. It keeps the skin inside your mouth and throat healthy. But vitamin A is especially important for your eyes. It keeps you from getting certain eye diseases, and it helps your eyes see better when the light is dim and even when it is dark. Aviators who fly planes at night eat extra amounts of vitamin A to help them see better. But everyone needs plenty of this vitamin to keep his eyes in good condition. Vitamin A is found in butter and is often put in margarine. Carrots, tomatoes, and spinach are vegetables that will supply you with vitamin A.

The vitamin in the brown rice is called vitamin B_1. Vitamin B_1 helps you grow properly and gives you a good appetite. We do not eat so much rice in our country as people do in the part of the world where the doctor discovered the material in the rice hulls. But we eat lots of wheat. Wheat grains are like rice grains. Wheat has most of the vitamin B_1 in the hull and in the part that grows into the new plant. In white flour, the hull and the part that makes the new plant are usually taken out. When this is done, we are losing vitamin B_1 from the flour. Whole-wheat flour does not have these parts removed, and so it has more vitamin B_1 in it.

If we eat bread and cereals that are made of the whole grain, we get the vitamin B_1 that we need. Scientists now know how to make vitamin B_1, and it can be put into white flour. Perhaps you have heard about or read about white bread that has been *enriched.* That means that vitamin B_1 has been put into the flour or into the dough before the bread was baked. Your mother can buy enriched flour to use when she bakes cakes and bread. Milk, cheese, liver, spinach, and many other vegetables have vitamin B_1 in them.

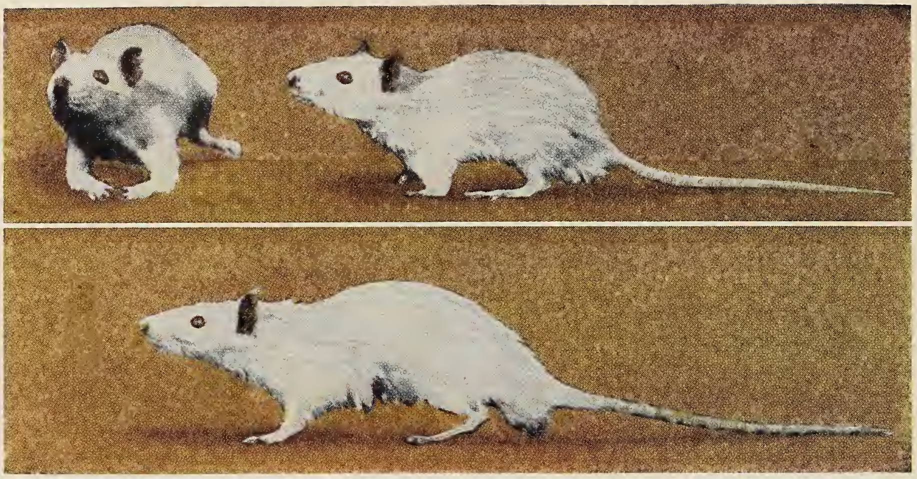
The vitamin in the lime juice is called vitamin C. Besides preventing scurvy, vitamin C helps your body heal when you cut yourself or burn yourself. It helps your body use the calcium in food for your bones and teeth. But your mother does not have to keep a bottle of lime juice for you to drink. Oranges, lemons, grapefruit, and tomatoes have vitamin C in them. Many other fruits and vegetables have vitamin C. You will get enough vitamin C if you eat plenty of fruits and vegetables.

Does your mother give you cod-liver oil during the winter? If you take cod-liver oil, you are taking it to get an extra amount of another very important vitamin. This is vitamin D. Vitamin D makes your bones grow straight and strong. It also helps your teeth. Children who did not get enough of this vitamin when their bones were forming and growing are often bowlegged. Other bones in their bodies may be badly formed, too, because of a disease. Scientists call this disease *rickets.* Vitamin D helps prevent rickets.



This baker is putting vitamin B_1 into the dough he is mixing.

Vitamin D is found mostly in fish. That is why you take oil made from the livers of codfish, halibut, and sharks if you need extra amounts of vitamin D. You also get it when you eat fish, liver, and egg yolks.



The rat on top had no vitamin D in his food. The one below had plenty of vitamin D. Do you think the vitamin D helped give this rat stronger bones?

But vitamin D is different from the others in one important way. Your own body can make vitamin D for you if you are in the sunlight enough. But in the wintertime there are many days when there is no sunshine. Also, when you play outdoors in cold weather, most of your skin is covered with heavy clothing. So in winter you may need to take an extra amount of vitamin D.

Sometimes foods are *irradiated* to give them more vitamin D. To do this, artificial sunlight is allowed to shine on the foods. Milk, butter, and margarine are often irradiated.

You probably hear people talk a lot about vitamins and the different kinds of vitamin pills. Usually you can get enough vitamins without taking pills. But you must eat the protective foods that contain vitamins.

---

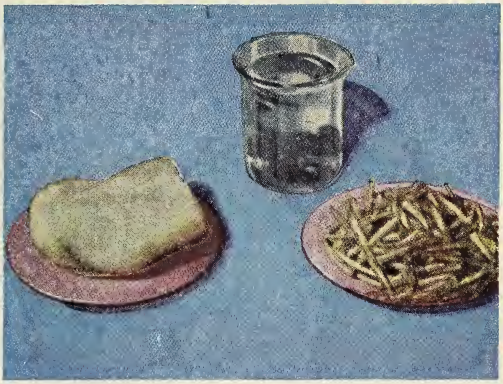
1. *What is a protective food?*
2. *Make a list of vitamins and tell what each vitamin does for you.*
3. *Make a list of vitamins and name some foods that contain each vitamin.*
4. *Why are scientists' experiments with food so important to you?*
5. *Should you take vitamin pills just because you heard someone say they were good for you?*

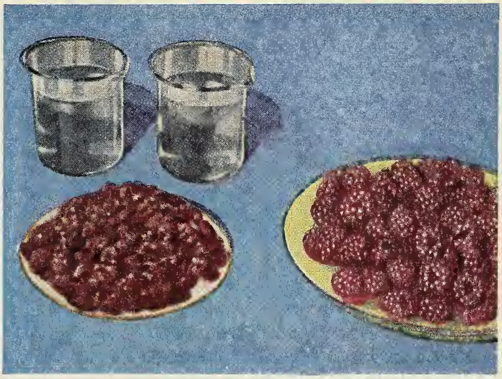
What does water do for your body?

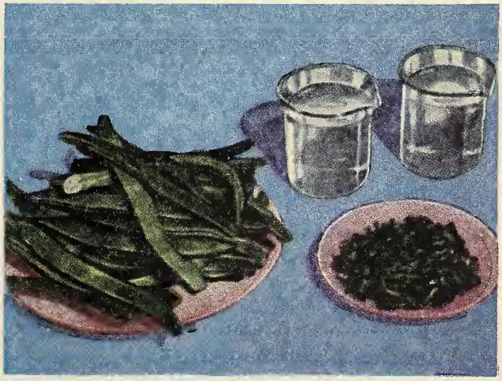
PROTEINS HELP your body grow. Fats and carbohydrates give you energy and keep your body warm. Minerals and vitamins help you grow and keep your body healthy. There is just one more thing your body needs to keep it well. That is water. Did you know that nearly three fourths of your body is water? You should drink at least four glasses of water each day. Your body needs much water because your blood is a liquid that is mostly water. You need water so that your body can keep on making the blood it needs.

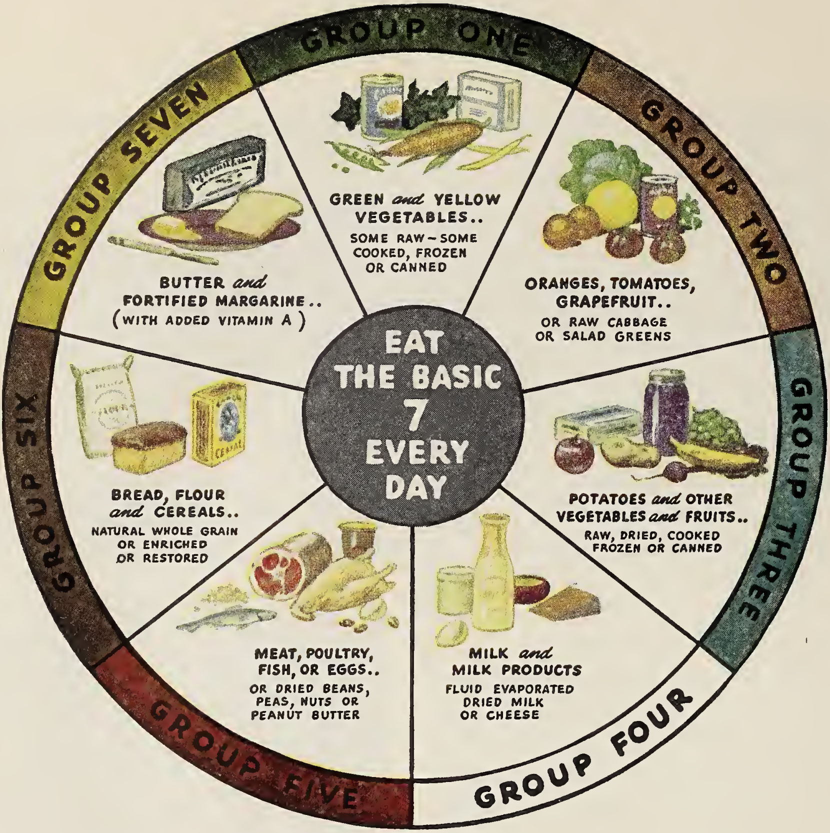
Water also acts like the cooling system in an automobile. Water helps keep your body at the right temperature. Water helps dissolve your food. Water carries off waste materials from your body. When you play hard or work hard, you perspire. Perspiration is water that is carrying some of the waste materials from your body.

Scientists know that a person loses four or five pints of water from his body every day. You cannot replace all of this water even if you do drink four glasses a day. But you can get water in milk, fruit juices, juicy fruits, and vegetables. Many things you eat have much water in them. Look at the pictures on this page. They show how much water you would get if you ate these amounts of potatoes, beans, or raspberries.





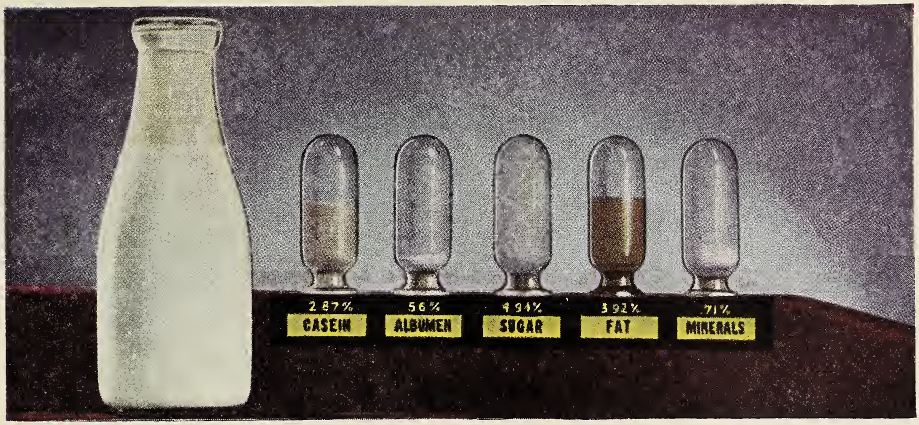



EAT THE BASIC 7 EVERY DAY
GROUP ONE
GREEN and YELLOW VEGETABLES..
SOME RAW – SOME COOKED, FROZEN OR CANNED
GROUP TWO
ORANGES, TOMATOES, GRAPEFRUIT..
OR RAW CABBAGE OR SALAD GREENS
GROUP THREE
POTATOES and OTHER VEGETABLES and FRUITS..
RAW, DRIED, COOKED FROZEN OR CANNED
GROUP FOUR
MILK and MILK PRODUCTS
FLUID EVAPORATED DRIED MILK OR CHEESE
GROUP FIVE
MEAT, POULTRY, FISH, OR EGGS..
OR DRIED BEANS, PEAS, NUTS OR PEANUT BUTTER
GROUP SIX
BREAD, FLOUR and CEREALS..
NATURAL WHOLE GRAIN OR ENRICHED OR RESTORED
GROUP SEVEN
BUTTER and FORTIFIED MARGARINE..
(WITH ADDED VITAMIN A)

What habits will help you get the proper foods?

YOU MAY THINK you need to spend most of your time eating to get all the fats, carbohydrates, protein, minerals, and vitamins your body needs. But if you remember the kinds of foods that have these materials in them, you can get all of them you need in your three meals a day. Luckily, many foods have more than one of these important materials in them.

The chart on this page shows you how to choose your foods so that you will get the right food materials. The foods have been divided into seven groups, called the *basic seven.* Basic means that they are the ones you cannot do without if you want to be really healthy. Each group does some one of the important things for your body that you have learned about. If you eat something from each group every day, you will be getting everything you need. "Eat the basic seven every day" is a good rule for you to remember.



Scientists can separate the different materials in milk and find out how much of each material there is in a quart of milk. Casein and albumen are the protein parts of milk that they find in the curd.

If you follow this basic-seven rule, you will have enough of all the different foods instead of eating too much of one kind and not enough of another. This does not mean that you should eat only the foods on this chart. But it does mean that you should be sure to eat these foods first. When you have formed the habit of eating these foods, you will probably find that you like many things that you thought you disliked. You can form the habit of liking foods instead of disliking them.

Why should you form the habit of drinking a quart of milk every day? Let us take some milk apart, so that you can understand why it is important to drink plenty of milk. First, take the cream off the top of a bottle of milk. Put it into a glass jar. You can churn this cream into butter by beating it with an egg beater or shaking it in a glass jar with a tight cover. What food material does this part of the milk have? It is fat. So you can see that milk has some fuel food in it.

The milk that is left after the cream is taken off is skim milk. Let this part stand until it is sour. Heat it a little. Some white, fluffy material appears. This is called the *curd*. Strain it, salt it, and you will have some cottage cheese. Curd has much protein in it. So you can see that milk has a body-building food in it.

The liquid part that is left is called the *whey*. Taste it. Is it sweet? There is sugar in it. Here is another fuel food. Heat the liquid in a shallow dish until it evaporates. What is left? This sticky material in the bottom of the dish has some sugar, calcium, and phosphorus in it. So you can see that milk has a carbohydrate and some minerals in it, too.

You have found four of the food materials that you need in this bottle of milk. Besides these four important food materials, milk also has vitamins in it. Do you see why milk is called the perfect food? You should drink a quart of milk every day.

Do you sleep so late in the morning that you do not have time to eat a good breakfast before you go to school? If you do, you are missing a very important meal. You are trying to run your body all morning without giving it enough fuel for energy. You need to eat a good breakfast to begin the day. A healthful breakfast gives you vitamin C. Oranges, grapefruit, the juices of these fruits, and tomato juice have good supplies of this vitamin.

For fuel food, you need some cereal and some buttered toast. If you use a whole-grain cereal and whole-wheat or enriched bread, you will get vitamin B_1 and some minerals at the same time. An egg for breakfast three or four times a week gives you protein and some of the minerals and vitamins. Sometimes when it is very cold or you are going to do a lot of exercising, you may want to eat bacon or sausage for breakfast. This fuel food tastes good, but you can usually get enough fuel food without it.

Milk on your cereal and a glass of milk to drink will give you some of the calcium and phosphorus you need as well as some vitamins. Coffee and tea are not good for you. They do not have any of the foods you need.

Look at the lists of your meals that you have been keeping. Do you always eat a breakfast that includes the foods you need? If you do not, talk

One pint of milk gives as much calcium as twenty servings of fruits and vegetables.

with your mother or your teacher about some way to get the kind of breakfast that is best for you. You will be surprised how much better you will work and play during the morning if you eat the right kinds of foods for breakfast.

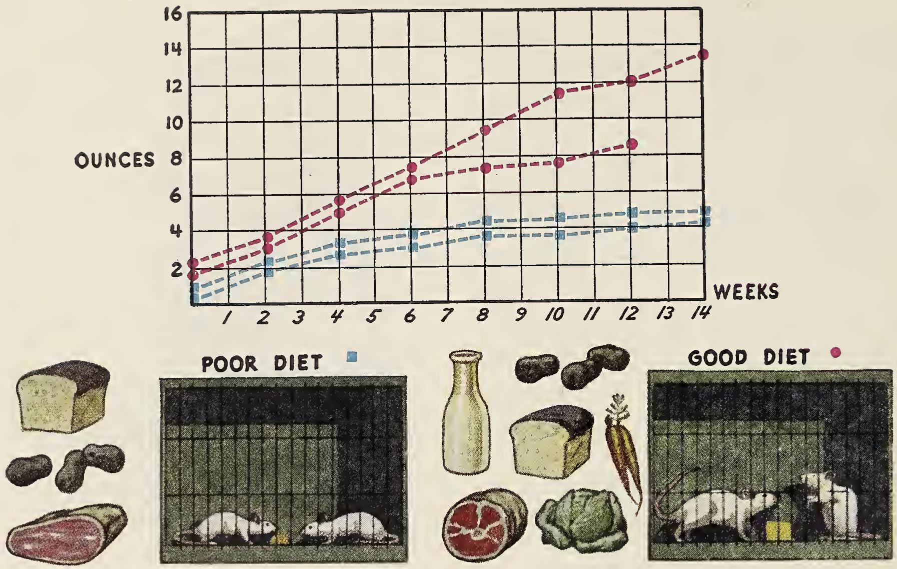
Do you have the habit of getting some of the basic seven for lunch? If you go home to lunch, your mother has it ready for you. But you may take your lunch to school or buy it in the school cafeteria. Do you eat a healthful lunch, or do you just drink some "pop" and eat some sweets, because they are the things you like best?

If you take your lunch, your mother can plan it so that you always get some of the basic seven. Your sandwiches can be made with whole-wheat bread and something like peanut butter, cheese, or chopped egg for the filling. You can take lettuce, carrots, a tomato, or some fruit to give you vitamins and minerals. If your lunch box has a thermos bottle, you can have milk. Or you may get milk at school. In the winter when it is cold, hot soup made with milk tastes good and gives you some of the milk you need every day. Some fruit or some molasses cookies make a good dessert. Molasses has much iron in it.

When you are picking out your food in the school cafeteria, you may find it much harder to choose the things you should eat. Sometimes you may want to eat one or two things you like instead of choosing a meal that has the different foods you need. But you can make a game out of choosing a lunch that tastes good and is also good for you.

The picture on this page shows a girl and the lunch she picked out. She has cream of tomato soup, milk, a whole-wheat roll and butter, and some lettuce salad. For dessert, she has apricots and oatmeal cookies. Has she chosen her lunch well? Why do you think so? Now look at your food list to see what you have been eating for lunch. Have you been choosing the proper foods?

Sometimes after school you are hungry. It is better to eat some fruit or drink a glass of milk than to eat



What does the experiment with the white rats show you about eating the proper foods?

candy or to drink "pop." Candy gives you energy, but it takes away your appetite for your meals. If you eat candy, it is much better to eat it right after lunch or right after dinner.

"Pop" is mostly water with some sugar and flavoring in it. Like candy, it will spoil your appetite. Then you will not feel like eating your dinner, because you do not have room for the foods that you need.

Dinner is very important. If you have been playing after school or working in your garden, you are hungry. Dinner is a good time to get some of the basic seven that you have not eaten during the day. Your dinner should probably start with meat and potatoes and one other vegetable. If you have not had any fresh fruits or vegetables during the day, a lettuce and tomato salad would be good. For dessert, you might have fruit or custard or some ice cream. To be sure that you have had your quart of milk for the day, drink a glass of milk with your dinner. Look at your food list again. Have you been eating healthful dinners? What can you do to improve them?

Planning meals is not always an easy job. But if you know the foods that give you the things you need, you can eat and be healthy. Of course, you do not need to remember just which vegetables and fruits have each vitamin and mineral. If you eat plenty of meat, fruits, vegetables, milk, butter, and whole-grain bread and cereals, you will get enough of the different food materials you need for good health.

If you were able to get some white rats, you have been feeding and watching the two groups as you studied this unit. How have they grown? Which group looks healthier? The rats that had all the different kinds of food are big, playful, and friendly. But the others are small and do not want to play. The two groups of rats have grown differently, and they act differently. You can see why it is important to eat the proper foods.

---

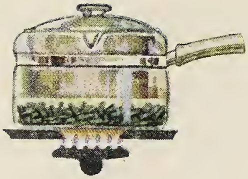
1. *List all of the things that you can do to make sure that you are getting the right foods.*
2. *Explain why you should eat some of each of the different food materials every day. Do your meals include these foods? How do you know?*
3. *What does this mean?* Eat the basic seven every day.
4. *Why is milk such an important food?*
5. *What have you learned about eating each of these?*
   Eggs Candy Whole-wheat bread Soup Vegetables

What does cooking do for your food?

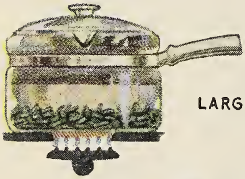
YOUR MOTHER has to do more than plan meals and buy food to give you something to eat. Before food can be eaten, it has to be prepared. And much of it has to be cooked. Your stomach could not digest some foods very easily if they were not cooked. Many foods would not be very appetizing to eat raw. People in some parts of the world eat raw fish and raw meat, but we are not used to doing that in our country. Another reason for cooking food is to kill germs. Certain germs can be killed only by cooking the food. But sometimes when food is cooked, the vitamins are destroyed and many of the minerals are lost.

There are many ways of cooking foods, and everyone has a favorite way of doing it. Some people like to fry a great deal of their food. Fried foods are harder for your stomach to digest than foods cooked in other ways.

As you know, vegetables are among the most important foods to eat to get the minerals and vitamins you need. But many of the minerals and vitamins are often lost while the vegetables are being prepared and cooked. Vegetables must be washed before



USING A SMALL AMOUNT OF WATER



USING A LARGE AMOUNT OF WATER

THROWING AWAY WATER FROM VEGETABLES

USING WATER FROM VEGETABLES FOR GRAVY

USING BEET GREENS

THROWING BEET GREENS AWAY

they are used, but they should be washed quickly. They should not be allowed to stand in water before they are cooked.

Cutting vegetables up into small pieces makes it even easier for the vitamins and minerals to be lost. When you peel potatoes, you take off the part that has most of the minerals. Baked potatoes or potatoes cooked with their skins on still have most of their minerals after they are cooked.

When vegetables are boiled in a lot of water, the minerals in the vegetables dissolve in the water. Some of the vitamins may dissolve in the water, too. Usually this water in which vegetables are cooked is thrown away. Then most of the minerals and vitamins you could get from the vegetables are lost.

To save these important food materials, vegetables should be boiled in as little water as possible. And they should be cooked only long enough to make them tender. If there is not too much water in the pan, the juice from the vegetables can be served with them. Then you will be getting all of the minerals and vitamins they have. This juice can be used in soups and gravies, too.

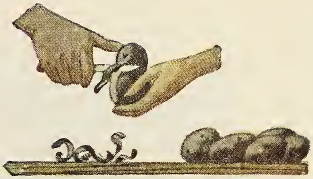
If meat is boiled or cooked with a great deal of water, the minerals, much of the fat, and some of the protein are lost from the meat. Roasting or broiling keeps most of the minerals and vitamins in the meat. So it is best to cook meats in these two ways whenever you can.

Water is not the only thing that takes vitamins from your food. Heat and air also destroy some of the vitamins. Fresh vegetables and fruits have most of their vitamins still in them. The longer they are exposed to the air, the more vitamins they lose. Cooking vegetables and fruits in pans that are covered as tightly as possible helps keep the vitamins in.

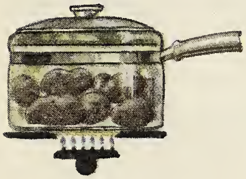
Very often canned vegetables and canned fruits bought in a store have more vitamins than the fresh ones cooked at home. The way they are cooked in a big canning factory keeps out the air. Not so many of the vitamins are destroyed. The juice is kept with the vegetables or fruits, and this has vitamins, too. A very healthful fruit drink can be made from the extra juices in cans of fruit.

Most of the milk you drink has been pasteurized. This means that the milk was heated to 145° F. and kept at that temperature for half an hour. Scientists have found that this kills the germs that may be in the milk. This heat destroys some of the vitamins. But eating other foods makes up for this. It is much safer to use pasteurized milk and get your vitamins from other foods.

In winter, you want to eat more hot, cooked foods. In summer when it is very hot, you do not need so

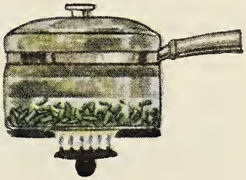


PEELING POTATOES

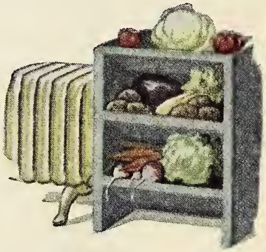


COOKING POTATOES WITH SKINS ON

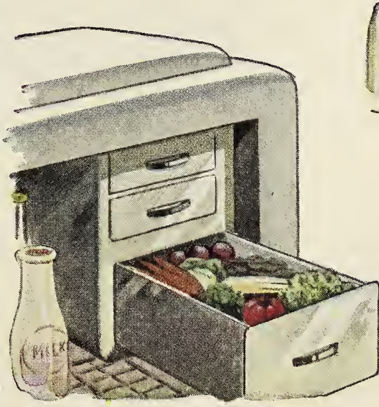
COOKING VEGETABLES IN UNCOVERED PANS



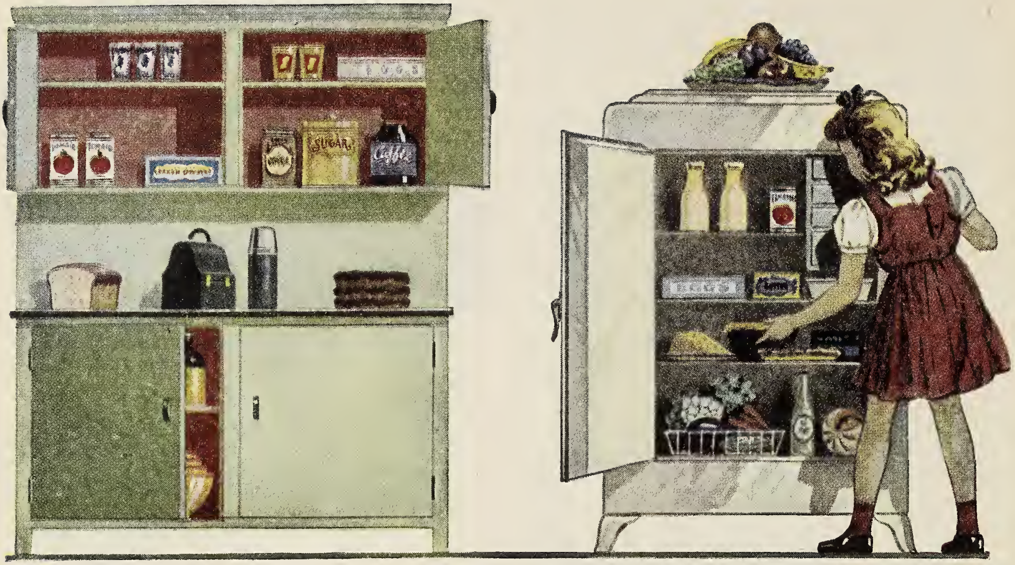
COOKING VEGETABLES IN COVERED PANS



KEEPING VEGETABLES NEAR HEAT



KEEPING VEGETABLES COOL



The girl in the picture is going to help her mother pack her lunch for school. What things could she put in her lunch to give her the proper foods?

much hot food unless you are doing very hard work. Lighter, cooler foods look better to you and satisfy your appetite. Setting the table neatly and attractively always makes the food look better and taste better, too.

1. *What are three reasons for cooking food?*
2. *Look at each pair of pictures on pages 200 and 201. Which one in each pair shows the correct way of preparing or cooking food? Explain your answer.*
3. *Why is milk pasteurized? How is this done?*

QUESTIONS TO ANSWER

1. Why are canned foods sometimes better than fresh foods?
2. How can the things you learned in this unit help you?
3. Why are experiments with the food of animals important to you?
4. This unit is called "Why do you need food?" Give your answer to this question.
5. Why do farmers who raise cows, sheep, chickens, and other animals need to know about foods?

THINGS TO DO

1. Newspapers and magazines often give plans for meals. Look at the meals to see if they are healthful. Cut out the best plans and make a book of plans for healthful meals.

2. Make a large basic-seven chart and hang it in your schoolroom.

3. Study the list you have made of the foods that you have eaten. Try to decide what you can do to improve your meals.

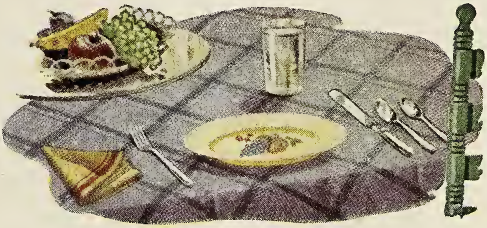
4. Find out more about experiments with animals and foods.

5. Think of some experiments to show that fruits and vegetables contain a large amount of water.

6. Ask your school nurse or a doctor to talk to your class about foods and good eating habits.

7. Explain why doctors are interested in getting people to eat the proper foods.

8. Make a collection of different kinds of empty cereal boxes. Read the labels and talk about the information given about each cereal.



★ *In Unit Eight You Will Learn* ★

★ How roots help plants get food materials ★

★ How water and air get into the leaves ★ How a green leaf makes food ★

★ What becomes of the food made by a green leaf ★

★ How plants that are not green get food ★

⋆ UNIT 8 ⋆

Where Does All the Food of the World Come From?

WHERE DOES ALL the food of the world come from? Perhaps that question is too hard for you to answer. Very well. Try answering this question. Where does all the food you eat come from? Perhaps your answer would be "From the grocery store and meat market." Or if you thought more carefully, you might say, "It comes from animals and plants." That would be a good answer, but it would not be the whole answer.

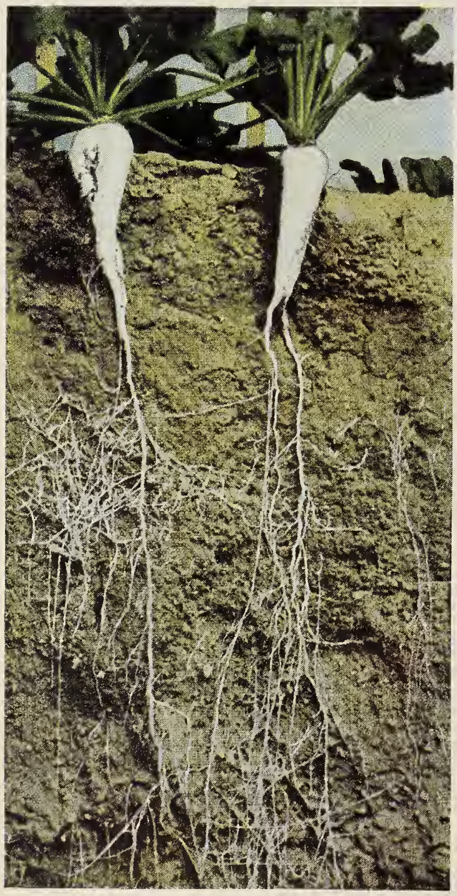
Suppose you think of all the kinds of animals you use for food—cows, sheep, pigs, chickens, turkeys, ducks, and fish. What do they use for food? Perhaps you say that turkeys and chickens eat insects, such as grasshoppers and crickets, as well as grain. And you may say that big fish eat little fish and frogs. That is true. But what do grasshoppers and crickets use for food? And what do little fish and frogs use for food?

Have you begun to guess where all the food comes from? In Unit Seven, you learned about carbohydrates, fats, proteins, and minerals. You learned why your body needs them. If it were not for green plants, you could not get these carbohydrates, fats, and proteins. Green plants make these foods, and we eat them when we eat the plants or the parts of plants. Green plants make these foods, and the animals we use for food eat the plants or eat other animals that eat the plants. Plants do not make minerals. But they take minerals from the soil and change them so that we can eat them. You know that the green plants are not making the food just for us. They are making it for themselves. It is their food as well as ours.

When you look at a green plant, you are looking at one of the world's food factories. Strange and wonderful things are going on inside the green leaves of the plant. It is doing something that the world's greatest scientists cannot do. Let us look carefully at a green plant. Then we can find out how it gets materials to make food.

How do roots help plants get food materials?

IF YOU JUST look at a green plant growing in the ground, you can see that there are only two places where that plant can get the materials it needs for making food. One place is the soil. The other place is the air. But plants cannot use soil and air for food any more than you can. They must take materials from the soil and from the air and make food out of them. If we want to discover how green plants do this, we have to study what their parts are and how they are put together.



Let us start our study of green plants by looking carefully at the roots. If you can, go out into a field or a vacant lot and dig up different kinds of plants. Do not try to pull them out. Take up plenty of soil with them and then wash the soil off so that you will not break the roots. Look carefully at the different roots. Are they all alike?

If you dug up several different kinds of plants, you probably found that the roots of the plants were not all alike. Some plants have one main root with several smaller roots branching out from it. The picture on this page shows some sugar beets. Do you see the large main root with the smaller ones branching from it? Carrots, beets, and radishes have roots like this. Some other plants have no main root. They have smaller roots like branches that spread out in every direction. If you dug up some grass, you found roots of this kind.

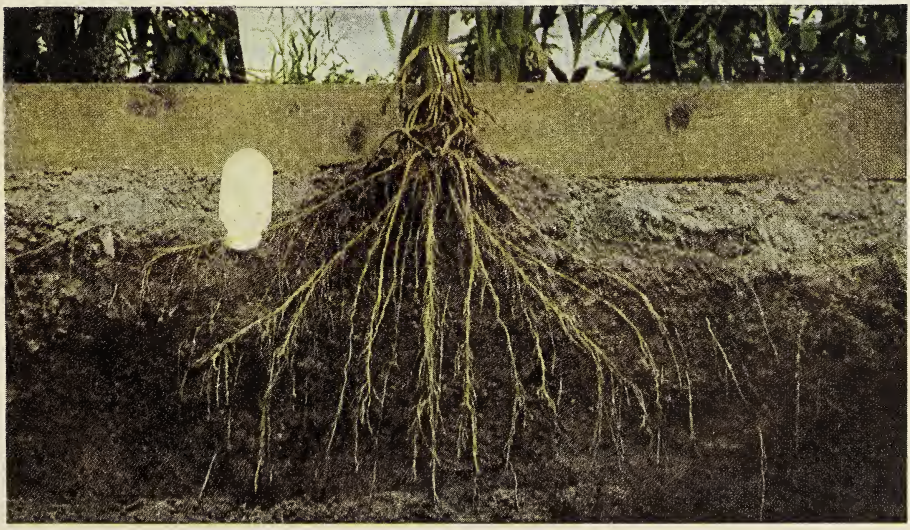
You already know that plants must have water to stay alive. You also know that they get this water from the soil through their roots. But do you know just how the water gets into the roots?

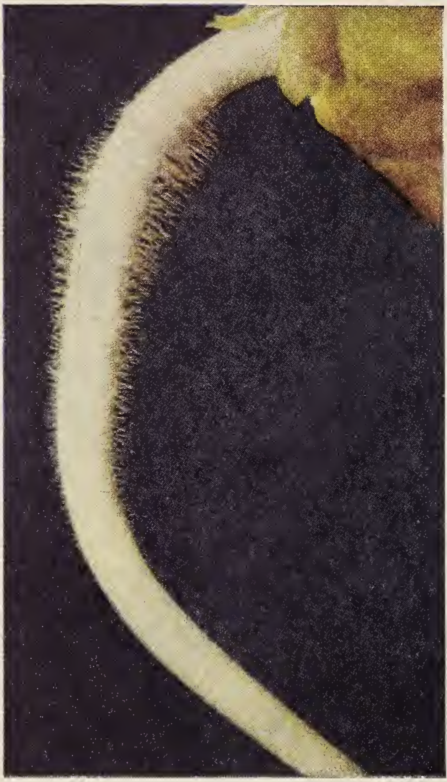
The large roots of a plant do not take in the water. The smaller roots that branch off from them do not take in water, either. But on these smaller roots there are very tiny parts as small as hairs. They are called *root hairs*. There are hundreds of these root hairs on one small root. They take in water for the plant. The outside of a root hair has a very thin covering. Water from the soil goes into the root hairs through this thin covering. From the root hairs the water goes into the root and then into the rest of the plant.

If you want to see how root hairs look, you can easily grow some. Put a dozen lima beans or several radish seeds on some moist blotting paper in a shallow dish. Do not cover the seeds with water but just keep the blotting paper moist. Keep the dish covered with glass so that the seeds will stay damp.

After the seeds have sprouted, take a magnifying glass and look at one of the roots. You will be able to see many tiny root hairs. Sometimes you can see them without a magnifying glass, because there are so many of them. The picture on page 208 shows

The roots of a corn plant are like grass roots. They spread out in all directions.





how these root hairs look. Once when some boys and girls saw the fuzzy root hairs on seeds that they had sprouted, they thought the plants were moldy and threw them away! They did not know that the fuzz that looked like mold was really thousands of root hairs.

When water from the soil goes into the root hairs of a plant, some very important materials enter with the water. They are minerals from the soil. You know the names of some of the elements in these minerals found in the soil. You have experimented with the elements iron and sulphur, and you know about calcium and phosphorus. You know that we need these elements in our foods. Now you know how they get into our foods from the soil.

Of course, the iron and other elements that the water gets from the soil are not in lumps like iron or sulphur you have seen. The elements are combined with other elements to form compounds that are minerals. These minerals are solids. They cannot get into the root hairs until they dissolve. Only those minerals that will dissolve in water can get into the root hairs. These minerals dissolve in the water that soaks into the ground when rain falls or snow melts.

All water in the ground has some kinds of minerals in it. Minerals are almost everywhere in the soil. They are some of the materials that a green plant needs for making food.

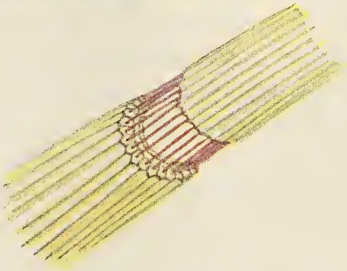
---

1. *Why must minerals dissolve in water before a plant can use them?*
2. *What parts of a root take in water?*
3. *What will happen if you cut off the root hairs of a plant? Try an experiment to see if your answer is right.*

After the water with its load of dissolved minerals soaks into the root hairs of the plant, it must get up to the leaves before it can be used to make food. How do you suppose the water gets to the leaves? An easy way to find out is to try this experiment. Get a stalk of celery with several leaves on it. Cut off about an inch of the bottom of the stalk. Fill a glass with water and add some red ink to the water to color it. Put the celery in the glass of colored water and set the glass on a window sill where it will be in the sunlight. After a few hours, look at the celery.

You will see that the red liquid has traveled up through tiny tubes in the stem and has gone into the leaves. If you break the stalk of celery, you can quickly find the tubes. They will be colored red by the ink in the water. You can easily take out one of these tubes and look at it. Or cut across the stem. If you can see the groups of red tubes, they will look like the picture on this page. Roots, trunks, and branches of trees and shrubs have tubes that carry water.

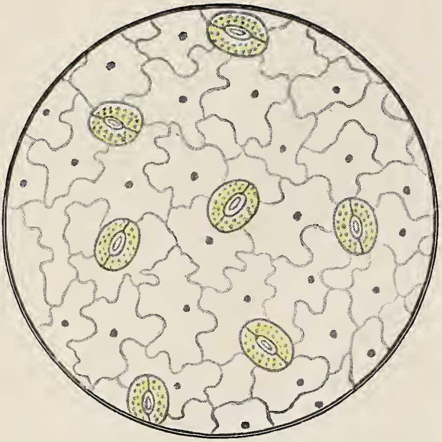
Now look at the leaves of the celery stalk that you put in the colored water. In what part of the leaves do you find the colored water? These colored places are the *veins* of a leaf. The tubes that carry water are in the veins.



What are the "strings" that you often find when you eat a piece of celery?

The water that has come up from the soil through the tubes in the stem travels through the veins of a leaf. On page 210 is a picture of a leaf that shows the veins. Do you see that they are in almost all parts of the leaf?

Now you have learned how water and the minerals dissolved in it get to the leaves of plants. Before you can understand how a plant makes



food, you will need to know some things about the parts of a leaf.

Plants need water and minerals to make food. They also need one of the gases in the air. People never really understood how air gets into a plant until they began to use microscopes. Then they could see how leaves are made. They found tiny openings on the undersides of the leaves, and they discovered that plants get air through these openings. These openings are really little doorways to let air come into the leaf. Study the picture on this page to see what the tiny openings look like. The picture on the left shows part of the surface of a leaf magnified thousands of times.

If you can look at a leaf under a powerful microscope, you will see hundreds of tiny green dots scattered through the leaf. They make the leaf green. The green material in them is called *chlorophyll.* You cannot see these little dots of chlorophyll except with a microscope. They are very small, but they are very important. No plant can make food unless it has chlorophyll in it. You may see some fungi that are green, but they do not have chlorophyll. They cannot make food. When we talk about green plants in this book, we mean only plants that have chlorophyll.

You have now found out five important things to help you understand how green plants make food.

1. The materials that plants need to make food are water, minerals, and one of the gases in air.
2. Minerals dissolved in water get into the plant through the root hairs.

3. The water and minerals go to each leaf through tubes in the roots and stems. They go to all parts of the leaf through tubes in the veins.

4. Air gets into the leaf through tiny openings in the leaf.

5. To make food, plants must have a green material called chlorophyll.

---

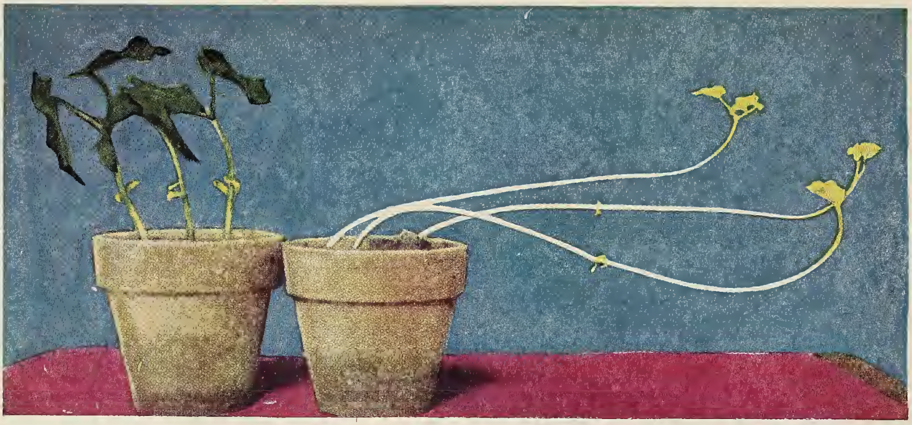
1. *What materials are needed by a green plant to make food? Where does each of these materials come from?*
2. *How does water get from the soil to a leaf of a green plant?*
3. *How does a green plant get the air it needs to make food?*
4. *Why was not all the celery stem colored by the red liquid?*
5. *What is one important use of a plant stem?*
6. *Florists sometimes sell green carnations. How do you suppose they make the white flowers green?*

How does a green leaf make food?

Now suppose that you could look inside a green leaf and could see what happens there as food is made. How does the plant make the carbohydrates, fats, and proteins that your body needs? The first food the green plant makes is sugar. From the sugar, the plant makes other kinds of food. It may seem strange to you that the sugar that is in your sugar bowl at home was once inside a leaf. But it was. When it was in the leaf, it looked quite different from the sugar that you eat.

You have eaten sugar made from a plant called sugar cane. You probably have eaten sugar from sugar beets, too. Have you eaten sugar from maple trees? Of course, you know that there is no sugar in the soil. And there is no sugar in the air. The green leaf made the sugar out of materials from the soil and the air. In the experiment on page 130, you heated sugar to separate it into the materials that it is made of. You found that sugar is a compound. Plants can make a compound by putting these materials from the soil and air together to make sugar, starch, and other kinds of foods.

Now let us learn a little about how a green leaf puts materials together to make food. Water with its load of minerals comes up from the roots, through the stems, and into the veins of the leaf. Air comes in through the tiny openings in the leaf. One more thing is needed before the leaf can begin making food. Can you tell what



The bean plant on the left was grown in the light for ten days. The one on the right was grown for ten days in the dark.

it is? Try this experiment to see if you can find out. Follow the directions carefully.

Get two plants that are about the same size. Put one on a window sill where the sun can shine on it. Put the other one in a dark closet or any dark place. Water both plants every day. Be sure that the one in the dark has plenty of air, just as the one on the window sill has. Why do you think this is important?

After a week has passed, bring out the plant that has been in the dark. Do the two plants still look alike? Are the leaves green on one plant but yellow on the other? Why does the plant that has been on the window sill look better than the other one? Is it because it had more water and air? What did the plant on the window sill get that the plant in the closet did not get?

If you did the experiment carefully, you found that growing plants need sunlight. Plants cannot make chlorophyll without sunlight. And without chlorophyll, plants cannot make food.

But you have not yet found out what happens to the water and the air in the leaf. Let us see what happens. You know that air is a mixture of gases. One of these gases is carbon dioxide. The green leaf takes carbon dioxide from the air, puts it together with water from the soil, and makes sugar. This is a chemical change.

If you put water and carbon dioxide together, you would get a mixture—soda water. But a green leaf makes a compound—sugar. It puts water and carbon dioxide together and makes a different material. The sugar is not like either water or carbon dioxide. A chemical change takes place in the green leaf.

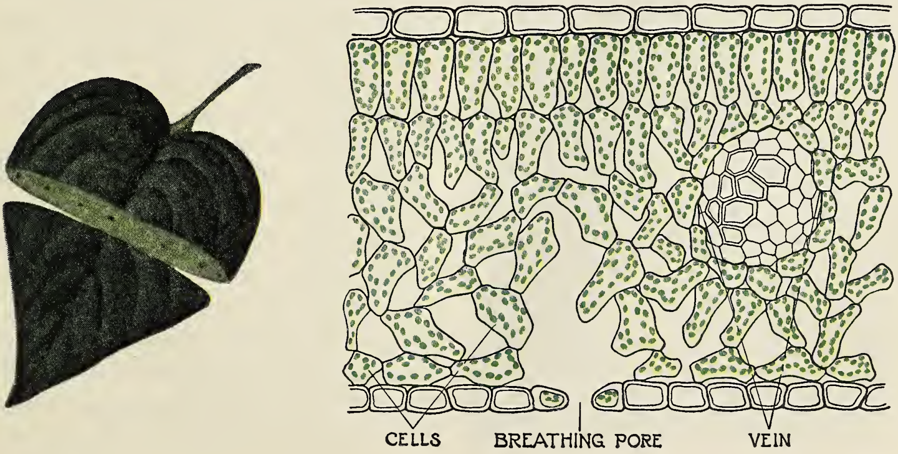
The chemical change takes place in the *cells* of the leaf. The picture on this page shows you what cells are. It shows how part of a leaf looks under a microscope. You can see that the leaf is made up of many tiny boxlike parts. These are the cells. The veins bring water and dissolved minerals to these cells. The openings in the leaves bring air to them. The chlorophyll is in these cells. The food is made in the cells.

Do you see now where the black carbon came from when you heated sugar? It was part of the carbon dioxide that the plant took from the air. A chemical change took place, and a compound was made inside the leaf.

This chemical change cannot happen without sunlight. Green plants cannot make food at night, and they cannot make it in dark caves in the earth. Deep down in lakes, oceans, and rivers, there are no green plants, because sunlight cannot go far down into the water. This chemical change cannot happen without the green-colored chlorophyll, either. Plants like mushrooms, puffballs, molds, and yeasts cannot make food. They cannot put water and carbon dioxide together to make sugar because they do not have any chlorophyll in them.

Scientists have studied the green plants for many years, but they still do not know just how a green plant makes food. They know that a plant needs air, water, minerals, chlorophyll, and sunshine. But scientists do not know exactly how the food is made. They know that sugar is made by the plant, because they can show

If you could cut a very thin slice down through a leaf and look at it under the microscope, you would see the cells and see where the chlorophyll is.



that leaves and other parts of plants have sugar in them. They also know that plants make starch. Sugar and starch are carbohydrates. Plants make fat and protein, too. Scientists do not know how the plants do this.

---

1. *What is happening in the green leaves you see?*
2. *Of what use is each of these in making food in a green leaf?*
   Water Sunlight Veins Tubes in the stem Air
3. *How do you know that the making of sugar by a green plant is a chemical change?*
4. *Why does the grass under a board get yellow?*
5. *In Unit One find a picture of a plant that cannot make its food. Why can it not make food?*

What becomes of the food made by a green leaf?

When we collect sap from maple trees, we get the sugar that was made in the leaves and stored in the plants all winter.

YOU KNOW WHAT becomes of some of the food the green plant makes. You eat it. But before you eat it, what does the plant do with it?

The carbohydrates, fats, and proteins made by the green plant are used by the plant in much the same way your body uses food. The food you eat is carried to every part of your body by the blood. In much the same way, the sap carries materials up and down in plants. You know that tubes carry sap, made of water and dissolved minerals, up to the leaves. The red lines in the picture on the next page show these tubes. Other tubes carry sap with food in it down from the leaves to all parts of the plant. The blue lines in the picture show these tubes.

Sap goes to every part of the plant. It goes to the stems, branches, roots, buds, flowers, and seeds. Some of the food in the sap is used to make the plant grow. The stems and roots get longer and thicker, just as you put on more flesh and your bones get bigger. The buds get larger and make new leaves and flowers. Every part of the plant must have food or it cannot grow.

Not all of the food that a plant makes is used while the plant is growing. Much of the food is stored in the plant. The tubes carry food to the roots, and some of it is stored there. If much food is stored in the roots, they become very large. Carrots, beets, radishes, sweet potatoes, and parsnips have big roots full of stored food.

Some of the food is stored in seeds. The food that is in bean and corn seeds was made in the leaves of the plant and was carried to the seeds. So was the food in wheat and other grains. All seeds have food stored in them. When we eat seeds, we eat this stored food. When we eat peas, corn, beans, and nuts, we are eating food that was made in leaves and stored in seeds. When we eat carrots, turnips, beets, and radishes, we are eating food that was stored in the roots. When we eat celery and asparagus, we are eating food that was stored in the stems. When we eat lettuce and cabbage, we are eating food that was stored in the leaves. Cows, horses, sheep, pigs, chickens, and other animals eat the stored food in plants, too.

But the plants also use this stored food for themselves. Many kinds of trees lose their leaves in the fall, but the trees are not dead. Food has been stored in their roots, trunks, and branches. The stems and leaves of many plants die during the winter. But their roots are in the soil and do not freeze. In the spring, the stored food in the roots is used. New stems and leaves begin to grow.

Many green plants store food in bulbs and use it in the spring to grow. Lilies, daffodils, hyacinths, and tulips have bulbs, which are big storehouses for food.

Food stored in the seeds of plants is used by the seeds when they begin to grow. A seed is just a tiny plant with food and a covering around it. When the lima beans or radish seeds sprouted and showed their root hairs, you probably noticed that as each little plant grew larger, the seed became smaller. It became smaller because the food inside the seed was being used up by the young growing plant.

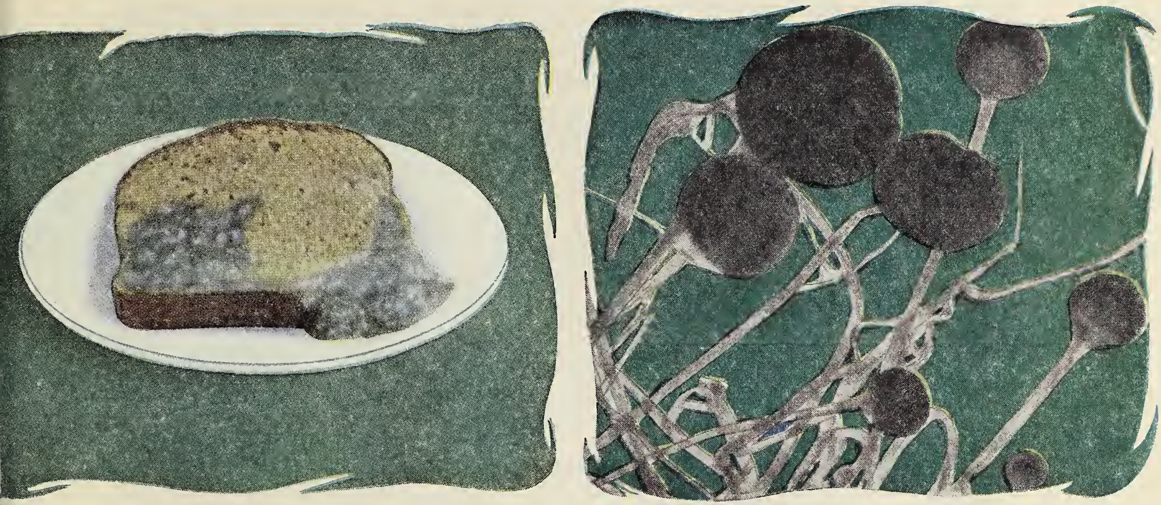
You have been learning about how a green plant makes food. The materials come into the plant through the root hairs and the leaves. The chlorophyll goes to work on these materials. The sun shining on the chlorophyll supplies the energy to make the chlorophyll do its work. The energy from the sun is changed to another form and stored in the food.

Without green plants you could not have anything to eat for your supper tonight. Do you see why? Suppose you were going to have roast lamb, potatoes, lima beans, lettuce and tomato salad, bread and butter, jelly, milk, and cake. Can you tell why each of these foods actually could not be on your table if green plants had not made food?

1. *A lion does not eat plants. It eats other animals. Does the lion depend on green plants for its food? Explain your answer.*
2. *What parts of plants have you eaten this week that had food stored in them?*
3. *How does food get from a green leaf to the stems, roots, buds, flowers, and seeds?*
4. *How does our supply of milk, meat, leather, and wood come from the food that was once in a plant?*
5. *What are two uses of the food stored in seeds?*

How do plants that are not green get food?

On page 24 you read that green plants sometimes help other plants by supplying them with food. Mushrooms, puffballs, and other fungi like the ones in the pictures on page 28 use other plants for food. These plants that are not green cannot change water and carbon dioxide into sugar and starch. They do not have the green chlorophyll that makes the



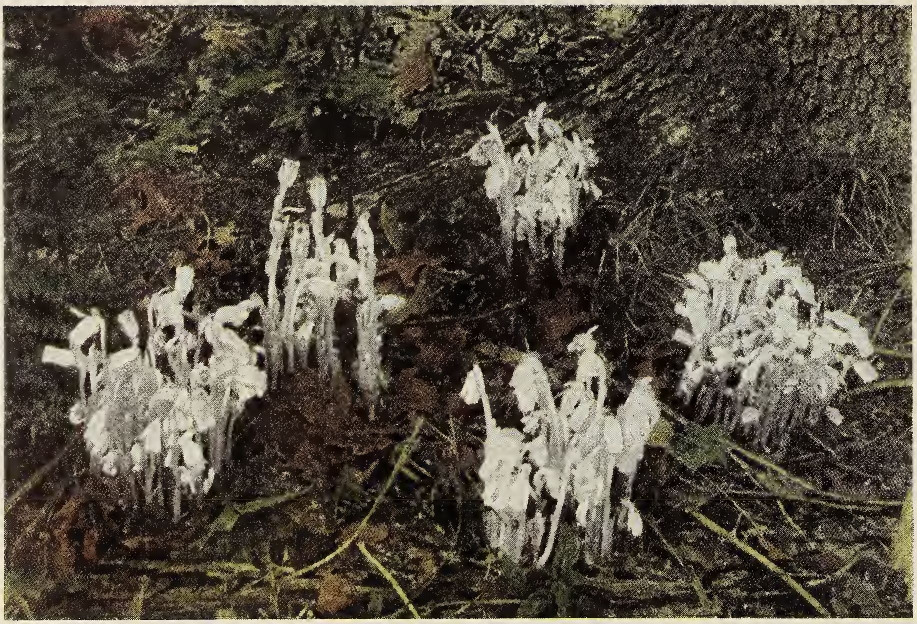
The picture on the left shows what will probably grow on the pieces of moist bread. The other picture shows you what bread mold looks like when you see it under the microscope. The little black balls contain the spores of the bread mold.

chemical change take place. So they have to use food that green plants have made.

You read about fungi in Unit One. Now suppose you grow some fungi. Bread mold is a fungus. It has no chlorophyll. Moisten a piece of bread, lay it in a dish, and shake a dusty cloth over the bread. Then cover the bread with another dish and leave it in a warm place for a few days. What do you see?

Look at the mold carefully. If you can see it under a microscope, it will look like the picture on this page. The bread mold sends little threads down into the bread. These threads are not roots. The threads soak up the food in the bread. This food was made by green wheat plants that grew in the soil, the air, and the sunshine. The food was stored in the seeds, or wheat grains. The grains were made into flour, and then the flour was made into bread. Mold will also grow on damp leather, meat, jelly, or almost any kind of food. Mold will even grow on live green plants and take in food that the plants are making.

If you have seen puffballs and other mushrooms growing in the soil, you know they are not green. They are growing up out of the soil, but they are not taking minerals from the soil and carbon dioxide from the air.



If you are ever walking in a damp, shady woods in the summer, you may find some of these strange white plants. They are called Indian pipes. As you can see, they have no chlorophyll. They get their food from the decayed materials in the soil.

They are just soaking in food from the bodies of plants and animals that have died and fallen to the ground. These bodies have decayed and become mixed with the soil. The sugar, starch, fat, and proteins that were in them went into the soil. Mushrooms and other plants that are not green just take in those foods that have already been made by green plants.

You almost never see mushrooms, puffballs, or other fungi growing on sandy beaches. They grow in fields and forests where there are plenty of plants and animals to die and become mixed with the soil.

---

1. *Make a list of different things on which you have seen mold plants growing.*
2. *When mold grows on foods, the foods decay. Is decaying a chemical change? How can you tell?*
3. *Tell why mushrooms cannot make their own food. Then explain how the foods they use were really made in green leaves.*

QUESTIONS TO ANSWER

1. If you sprinkled water on the leaf of a plant, would the plant be able to use the water to make food? Why?

2. When plants are moved from one place to another, why should you be very careful not to damage the roots?

3. Why would we have no food if the sun did not supply energy?

4. Explain as carefully as you can how a plant makes food.

5. How do you think coal, oil, gas, and wood get the energy that is stored in them?

6. Should a tree be watered close to the trunk or several feet away from the trunk? Explain your answer.

THINGS TO DO

1. Sprout some different kinds of seeds on moist blotting paper and look for the root hairs.

2. Place the stems of different kinds of white flowers in colored water. Watch to see what happens. Find the tubes in the stems, leaves, and flowers.

3. Make a collection of plants that do not have chlorophyll.

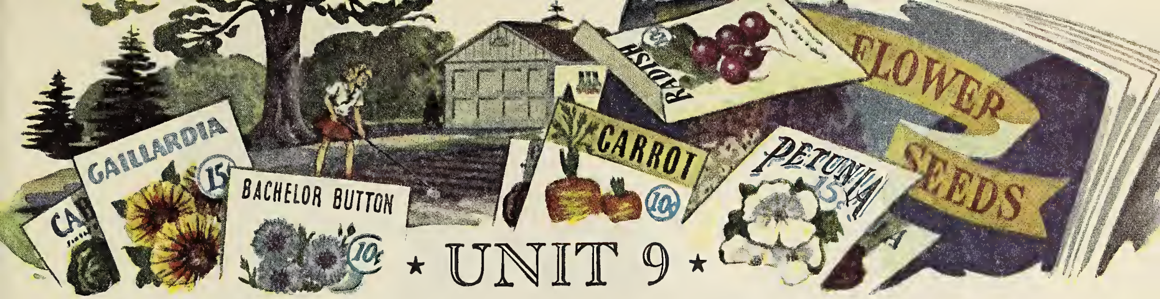
4. Bring samples of different materials on which mold is growing. Look at the mold with a magnifying glass.

5. Look at the branches of bushes, trees, and house plants to see how the leaves are placed so that each leaf will get plenty of sun. Draw a picture to show how the leaves grow.

6. Find out what a taproot is.

★ *In Unit Nine You Will Learn* ★

★ *How you can plan a garden* ★ *How we get the soil ready for planting* ★
★ *How we plant a garden* ★ *How we take care of growing plants* ★
★ *How plants are protected from their enemies* ★



★ UNIT 9 ★

How Can You Make a Garden?

"It will soon be time to start our garden," said Mr. Bates to his family one morning in early spring.

"You're joking," said Betty. "It's still cold outdoors."

"And the weatherman says we are going to have cold rain changing to snow," added Bill.

"I don't mean digging in the ground and planting seeds," explained their father. "There's more to gardening than that. Before we plant anything, we ought to plan our garden. We should decide what things we are going to grow, where we are going to plant them, and how much we want of each thing."

"Oh, I'd love to have a big flower garden," Betty said. "Then I could pick all the flowers I wanted."

Bill frowned. "Flowers are all right, I guess. But you can't eat them. I want to grow a lot of carrots and radishes and corn and beans."

"Now just a minute, children," laughed their mother. "We can have a flower garden and a vegetable garden, too. Let's look through these seed catalogues and pick out the things we want."

"I think we ought to read a book about gardening, too," Mr. Bates said. "I brought one home the other day. We can read it together."

In the gardening book, they found a list of rules to follow. They were called Guides for Good Gardening. Here they are.

GUIDES FOR GOOD GARDENING

1. Do not start a bigger garden than you can finish.
2. Do not plant too much of one thing.
3. Do not waste good seed on bad soil.
4. Do not use too much seed.
5. Do not let the weed crop win.
6. Do not let the insects eat your garden.

You can probably give some reasons for each of these rules right now. But as you study this unit, you will learn more about why they are good rules to follow. Perhaps you will want to copy them on a big piece of paper and hang them up in your room at home or at school.

How can you plan a garden?

Do you want to have a garden this spring? If you cannot have one at home, perhaps you can have one at school. You will find that gardening is a lot of fun. But you will enjoy your garden more if you can be proud of it. To have a good garden, you must think as well as work. You must plan your garden carefully. So start planning it early.

Are you going to have a vegetable garden or a flower garden or both? What kinds of vegetables or flowers do you want? How big will your garden be? Where will you have it? You should be able to answer all these questions before you plant anything.

The rule about not starting a bigger garden than you can finish is very important. If you have never made a garden before, start with a small one. You will probably be surprised at how much work you must do to take care of even a small garden. A good size to begin with is a garden ten or twelve feet long and four or five feet wide.

You should also follow the rule about not planting too much of one thing. When Mr. Bates read this rule to his family, he laughed.

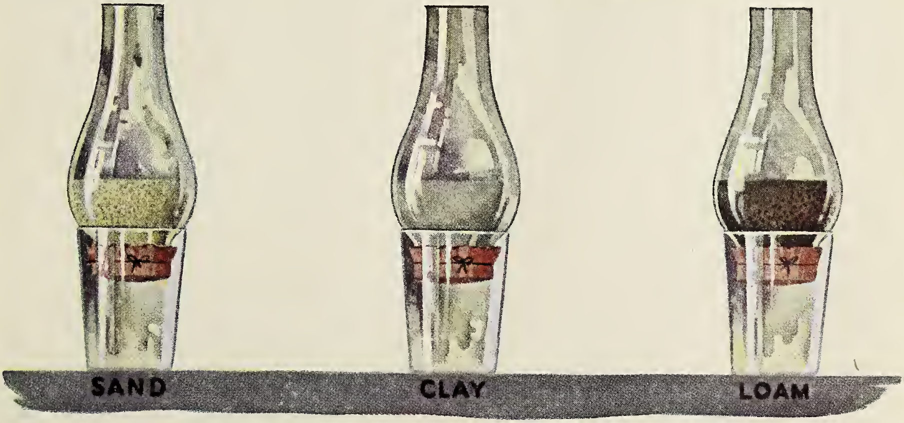
"What's funny about that?" asked Betty.

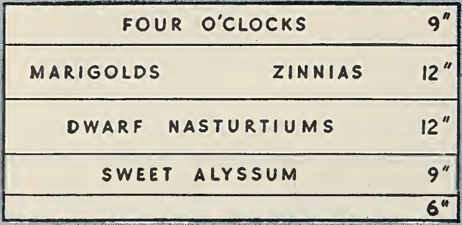
"Well," said her father, "I was just thinking of the first garden I ever had. I planted four long rows of radishes. When they were ready to eat, we had so many radishes we didn't know what to do with them. We had radishes for lunch and radishes for supper. We gave them away to our neighbors. I even tried to sell them, but everyone else must have planted a lot of radishes, too. So let's be careful not to plant too much of one thing in our garden."

You know that green plants must have sunlight, air, and water to make their food. Keep this in mind when you pick out a spot for your garden. If you can, choose a place where the sun will shine on the plants all day. Be sure that trees, bushes, buildings, and fences will not shade your garden most of the time. Put tall plants on the north side of your garden and short plants on the south side. Then both will get plenty of sunlight.

The next rule, about not wasting good seed on bad soil, is also very important. So you should find out if the soil in the spot you choose for a garden is mostly clay, sand, or *loam.* Moist clay is sticky, and dry clay is almost as hard as rock. Sand is gritty. It falls apart even when it is wet. Loam is a mixture of sand and clay with some decayed material from plants and animals in it. This decayed material that is formed from the dead bodies of plants and animals is called *humus.* You can easily learn to tell one kind of soil from another.

This experiment shows you why you should know what kind of soil there is in your garden. Get three lamp chimneys and tie a piece of cloth over the bottom of each one. Also get a cupful of sand, a cupful of clay, and a cupful of loam. Be sure that each kind of soil is dry. If it is moist, dry it in an oven or other warm place. Pour the sand into one chimney, the clay into another chimney, and the loam into the third chimney. Press the soil down firmly in each chimney. Then set each chimney in an empty glass as shown in the picture.

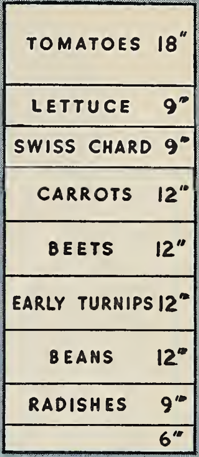




Front of garden

FLOWER GARDEN

VEGETABLE GARDEN



Front of garden

Fill three other glasses with water. Give a glass of water to each of three members of your class. Have each one pour his glass of water into a chimney at the same time as the others do. Watch and see which kind of soil lets the water through first. Does the water run through the sand first? Then after a while does some of the water come through the loam? Does the clay hold the water so that it does not run through?

If soil is mostly sand or clay, plants cannot get the right amount of water. Sand drains so fast that roots cannot get enough water. Clay holds so much water that roots will rot. Moist clay sticks together tightly, and air cannot get into the soil. You can see why loam is the best soil for a garden. It holds water better than sand, and it drains better than clay.

When you decide what to grow and where to have your garden, draw a plan like the ones on this page. Use lines for the rows of different plants you are going to grow. The distance between the rows depends on how big the plants are when they are full-grown. You can find out many things about planning your garden in seed catalogues. Usually they tell just how far apart the rows of different plants should be.

---

1. *Give several reasons why a garden should be planned.*
2. *Tell why each of the first three rules for gardening given on page 221 is important.*
3. *How would you pick out a good place for a garden?*
4. *For the experiment on pages 223-224, you must have dry soil. Tell why it is needed.*
5. *Why is loam better than either sand or clay for growing plants?*

How do we get the soil ready for planting?

You can think of your garden as a little farm. A farmer does the same things you must do to make a garden. He must decide what things he will plant and where he will plant them. Then he must get the soil ready for planting. You can do this with your hands and a few tools. But a farmer needs machines and many different kinds of tools to help him with his work, because his fields are so much bigger than a garden.

To get the soil ready for planting, you must first loosen it and break it up. You cannot do this if the soil is too wet. If a lump of soil crumbles when you hit it, the soil is just right to work. But if it sticks together, it is too wet. You will have to wait until the soil is dry enough to work. Use a spade or a spading fork to dig into the soil and loosen it. Break up the lumps with a hoe or a rake. Then smooth the soil with a rake.

A farmer uses a plow to loosen the soil and break it into big chunks. These must be broken up into smaller pieces, and then the soil must be smoothed. To do this, a farmer uses a tool called a *harrow*. This has sharp disks or long, pointed teeth that cut into the soil and break it up. Sometimes a harrow is pulled behind a plow. Then the soil is plowed and harrowed at the same time.

Loosening and breaking up the soil make it easier to plant seeds down where they start growing best. And

The man in the picture on the left is plowing. In the other picture, a farmer is using a disk harrow to break up the big lumps of soil.

the soil can help keep the water that plants need. Water easily soaks into the ground when the soil is loosened and broken up. But if the ground is hard, much water runs off instead of soaking in.

While you are getting the soil ready for planting, remember the rule about not wasting good seed on bad soil. If the soil is poor, you can do several things to improve it. Loam is the best soil for your garden. You can make the soil more like loam. If the soil is too sandy, mix some clay and humus with it. If it contains too much clay, mix in some sand or ashes and some decayed material. Seed stores also sell a material called peat moss which is made of decayed plant materials. It can be used to make sandy soils or clay soils better for growing plants.

Have you ever heard of sour soil? It is soil with too much acid. Many plants will not grow well in sour, or acid, soil. In Unit Five you learned how to use blue litmus paper to test for acid. Put some moist soil from your garden on some blue litmus paper. If the paper turns red, the soil has acid in it. To make it less acid, put lime or ground-up limestone on the soil.

The soil may need fertilizer, too. You know that plants use dissolved minerals in the soil to make food. Plants take minerals from the soil all the time they are growing. But if the soil does not have the right minerals in it, plants will not grow properly. Then we have to find some way to put the minerals into the soil.

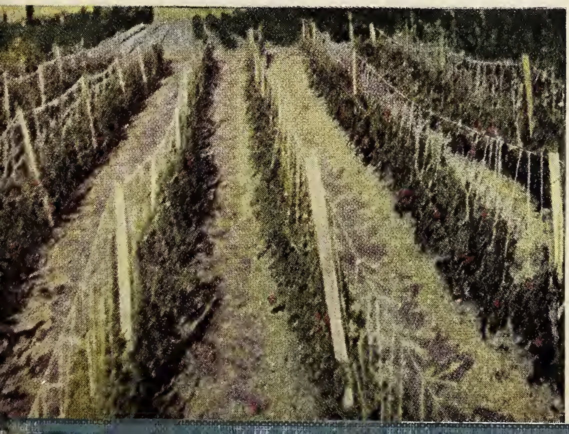
If we let plants die and decay, the minerals in them will slowly soak into the ground. Then other plants can use them to make food. But in a garden or on a farm we harvest the plants and take them away. Most of the minerals do not get back into the soil. Some plants, like corn or potatoes, use up the minerals very fast. After these plants are grown in the same soil for several years, there are not enough minerals left to raise a good crop. Then a fresh supply of minerals must be put back into the soil. One way to do this is to use fertilizer.

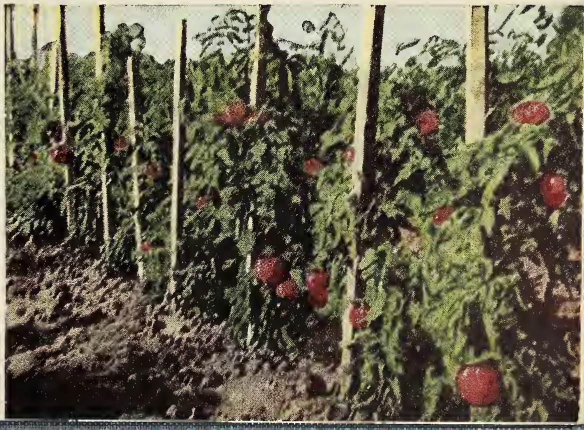
You can do an experiment to see what happens when soil is fertilized. Fill two flowerpots with soil that has been used to grow plants for a long time. Plant the same kind of seeds in each pot. Give them both the same amount of water at the same times. Set them side by side in a place where they will get the same amount of sunlight. When the plants come up above the soil, put some fertilizer in one pot. You can get the right kind of fertilizer from a florist. Follow the directions carefully so that you use just the right amount of fertilizer. Then watch the plants in the two pots to see which ones grow better.

Fertilizer contains the minerals that plants need. By doing many experiments, scientists have found out what elements in these minerals are used by plants. Without nitrogen, a plant will not have healthy, green leaves. Phosphorus helps the roots grow and makes plants develop faster. Potassium also helps roots grow. And it makes the stems strong and helps the seeds form. A plant must have magnesium to make chlorophyll. Without an element called boron, a plant may have brownish flowers and stems. If a plant cannot get manganese, its leaves may turn yellow. Plants also need calcium, sulphur, iron, copper, zinc, and possibly a few other elements.

The pictures on this page show you that plants need these elements. The tomatoes in the left-hand picture were grown without copper, zinc, manganese, or boron. The ones on the right were fertilized with these four elements. Which ones look like better tomato plants?

Scientists know how to test soil and find out what elements it contains. Then they can tell what elements should be added to make plants grow better. Each state has one or more experiment stations, where scientists





test soil. A farmer can send soil to an experiment station to have it tested. Or he can buy a set of chemicals and test the soil himself.

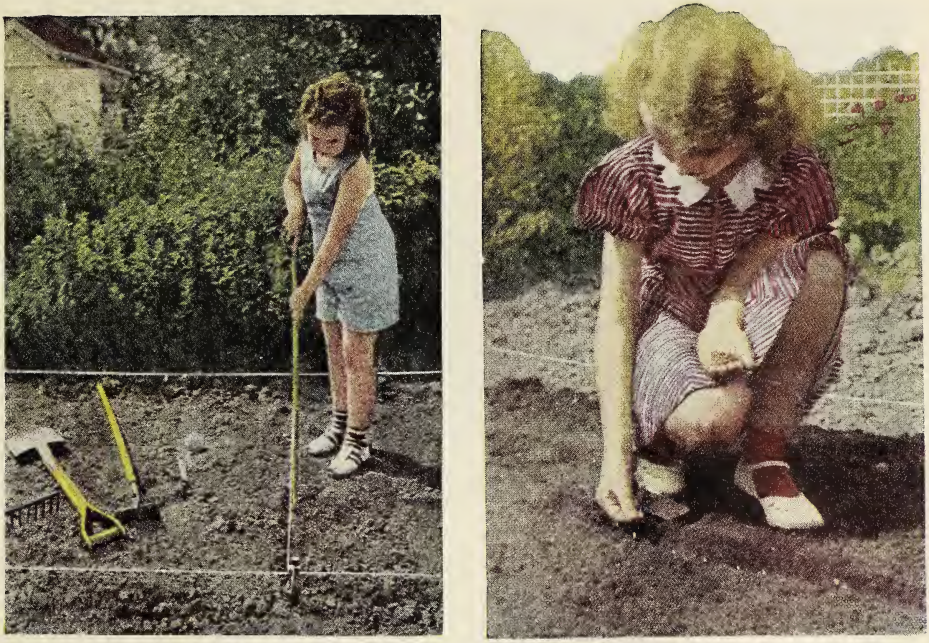
Fertilizer puts minerals back into the soil, but the right kind and amount must be used. The wrong kind or too much of the right kind may injure plants instead of helping them. Before you put any fertilizer on the soil in your garden, talk with someone who knows about the different kinds. Find out what kind to use and then follow the directions carefully. Spread the fertilizer evenly over the soil. Then mix it into the soil with a hoe or a rake. If you sprinkle the ground with water, it will help the minerals dissolve.

There are many different kinds of fertilizer used to make plants grow better. One kind is animal manure. It is a good fertilizer, because it contains nitrogen, phosphorus, and potassium. Usually it contains dead plant material, too. And so it adds humus to the soil. In the fall, the manure is often put on gardens and farm fields or around trees and bushes. During the fall and winter, it decays. Rain and melting snow dissolve the minerals. They soak down into the soil where plants can use them.

When the ground is spaded in the spring, the manure can be turned under. To do this, just turn the spadeful of earth over when it is put back into the hole. Then the manure will be in the soil.

Farmers have another way of putting minerals back into the soil. If corn or certain other crops are grown in the same field year after year, the crops become poorer and poorer. Minerals are taken from the soil and not put back. Corn takes a lot of nitrogen from the soil. But clover, alfalfa, soybeans, and cowpeas put nitrogen back into the soil. So farmers plant corn in a field for a year or two. Then they plant clover, alfalfa, soybeans, or cowpeas in the same field for a year or two. This keeps the soil from losing all of its nitrogen.

1. *Give two reasons for loosening and breaking up soil.*
2. *If the soil in your garden is too sandy, what can you do to improve it?*
3. *Why is lime or ground-up limestone sometimes put on soil?*
4. *When do plants take minerals from the soil? When do they put minerals back into the soil?*
5. *Before putting fertilizer on your garden, what should you find out?*
6. *How are a garden and a farm alike? How are they different?*



Marjorie is using a garden line to guide her in making a straight furrow. Jane is planting beet seeds in a furrow.

How do we plant a garden?

NOW COMES THE FUN of planting your garden! Everything else is done. You have decided what to grow, and you have drawn a plan of your garden. The soil is ready for planting. The next thing to do is to follow your plan in laying out the garden.

Use a string to make straight rows. The string should be a little longer than one row. Tie a stake to each end of the string. Push the stakes in the ground so that the string is tight and right over where you want a row of plants. Then make a furrow directly under the string. To make a furrow, you can use the end of a stick or the handle of your hoe or your rake, as the girl in the picture is doing.

Look at the different kinds of seeds you are going to plant. Some are probably larger than others. Large seeds should be planted deeper and farther apart than small seeds. The depth that the furrow should be depends on the size of the seeds.

For little seeds, such as carrots and lettuce, make a furrow about one-fourth inch deep. Remember the rule about not using too much seed. Take a few seeds at a time and scatter them evenly in the furrow. Cover them with about one-fourth inch of fine soil. Press the soil down hard with your hand all along the row. You do this to make sure that moist soil touches the seeds.

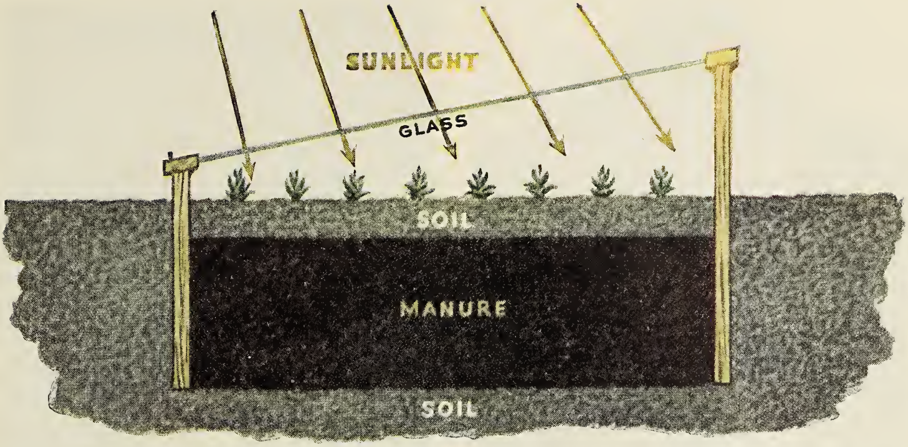
For medium-sized seeds, such as beets and radishes, make a furrow about one inch deep. Scatter the seeds evenly in the furrow and then cover them with one-half inch of fine soil. Press down hard on the soil with your hand all along the row.

For big seeds, such as beans and peas, make a furrow about two inches deep. Put the seeds about one and one-half inches apart in the furrow. Cover the seeds with a little more than an inch of soil. Press the soil down firmly with your hand.

You should also know when to plant different kinds of seeds. Read the directions in seed catalogues or on packages of seeds to find the best time for planting. In the early spring while it is still cool outdoors, you can plant carrots, lettuce, beets, radishes, and spinach. The seeds will sprout and grow. But you should not plant beans, peas, corn, cucumbers, or squash while it is cool. The seeds of these vegetables will not sprout until the weather is warm.

Some vegetables and many flowers take a long time to grow. They should be started early, but their seeds will not sprout until it is warm. If you wait for warm weather to plant tomatoes, peppers, cabbages, and eggplant, the vegetables will not be ready to eat before cold weather comes again in the fall. Do you know how we start plants like these growing early? We make a warm place for the seeds to sprout.

Have you ever seen a *greenhouse?* It is a building with a roof and walls made of glass. When the sun shines, its heat warms the soil inside where plants are growing. The soil warms the air in the greenhouse, and the glass keeps the warm air from getting out. It also keeps cold air, snow, and rain from getting in. At night or on cloudy days, a furnace heats the green-



When the days begin to get warm, the glass on the hotbed should be raised a little during the middle of the day. This gives the plants air and keeps them from getting too warm.

house. Even in winter, vegetables and flowers can be grown.

Plants can be started early in a greenhouse. You can buy these plants to put in your garden, or you can grow them yourself. You do not need a greenhouse to do this, but you can use something like it. Look at the picture on this page. It shows how a *hotbed* is made. A frame is set in a hole about two feet deep. The frame should be lower on the south side than on the north. Inside the frame, there is a layer of manure about eighteen inches deep. A layer of good soil about six inches deep is put over this. After seeds are planted in the soil, a glass cover like a big window is set on top of the frame.

The sun warms the soil in the hotbed, and the soil warms the air. The glass cover keeps the warm air in and the cold air out. The manure also helps warm the soil. You know that manure decays. As it decays, a chemical change takes place. This produces heat, which warms the soil above the manure. The seeds sprout in the warm soil, and the plants begin to grow.

Another way you can get plants started early is to use a *cold frame.* This looks like a hotbed, but it has no layer of manure under the soil. Only the sun warms the soil in a cold frame. So the growing plants are not kept as warm as they are in a hotbed.

Plants should be kept in a cold frame or a hotbed until there is no danger of freezing weather. Then the little plants can safely be taken out and set in the soil of your garden.

This is called *transplanting*. When you transplant, take up some soil along with the roots of each plant. Then make a hole in the soil of your garden. Be sure that the hole is big enough to hold the roots of one little plant. With your fingers, pack the soil down firmly around the roots but be careful not to injure them.

It is fun to plant a garden, and it is fun to watch it grow. But probably the most fun comes when you pick the vegetables and flowers. You may want to know how much of each thing you raise. If you do, you can keep a record of all the things you pick in your garden. Write down the day of the month when you pick each thing.

---

1. *Would you plant peas, carrots, and radishes in the same furrow? Why?*
2. *If you plant cucumbers, lettuce, beans, corn, and beets in the early spring, which ones will probably come up? Which ones may not?*
3. *How are plants started early while it is still cool outdoors? Name three ways and tell how each one works.*
4. *Tell how to transplant cabbage plants or tomato plants.*

How do we take care of growing plants?

FOR SEVERAL DAYS after their garden was planted, Bill and Betty went to look at it. Nothing seemed to happen. So they stopped going to see it every day. Then one afternoon Bill came running toward the house. He was very excited.

"It's up!" he shouted.

"What's up?" asked Betty.

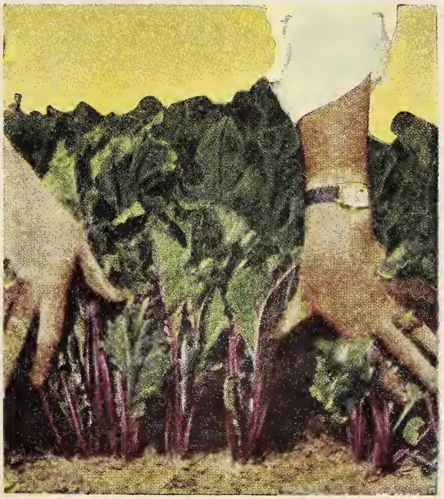
"Our garden," answered Bill. "It's really growing. You can see the little plants. Come and look."

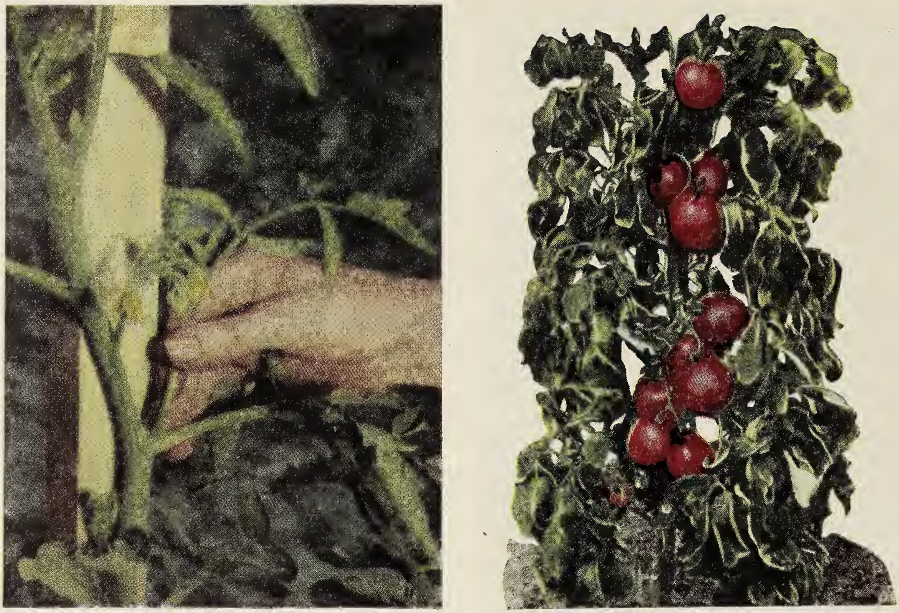
You will probably be excited, too, when you see the first plants coming up in your garden. You planted the seeds yourself. They sprouted in the warm, moist soil. And they are growing. From now on, you will be busy taking care of the growing plants.

When you planted your garden, you left spaces between the rows. If the rows are far enough apart, the plants in one row will not keep plants in another row from getting enough sunlight, water, and minerals. But if plants in the same row are too close together, they will not grow into healthy plants. None of them can get enough sunlight, water, and minerals.

After the plants have come up several inches above the ground, you may find that there are too many of them in one row. So you must *thin* the plants as soon as they are big enough to handle. To do this, you pull out some of the plants and leave more room between the others. You may not like to pull out plants that are growing. But you know why you must do it. You do it to give the other plants room to grow. The picture on this page shows how far apart beets should be after they are thinned. Pulling out some will make the ones that are left grow bigger.

Have you ever seen men cutting branches from fruit trees in an orchard? This is called *pruning* the trees. Some of the smaller branches are cut off so that the other branches can get more sunlight, food, and water. Pruning helps the trees grow bigger and better fruit. The roots take in only so much water and minerals, and the leaves make only so much food. When the smaller





Someone is removing a sucker from a tomato plant in the picture on the left. The other picture shows a tomato plant that has been pruned so that there is just one main stem.

branches and their buds are cut off, those that are left get more food.

At a fair or a garden show, you can see big, beautiful flowers, fruits, and vegetables. Many of them are grown by pruning the plants. All the buds except one at the end of the stem are cut off. Then this bud grows big because it gets all the food. You may not win a prize at a fair or garden show with your flowers or vegetables. But you can make some of your plants grow better by pruning them.

If you prune tomato plants, you will get bigger tomatoes. You will see that little shoots, or *suckers,* grow out at the place where the big leaves come from the stem. Pinch these shoots off with your fingers or cut them off before they grow very big. Every few days, look at the plants and remove any new suckers.

While you are down on your knees thinning or pruning the plants in your garden, you can do something else. Do you remember the rule about not letting the weed crop win? Weeds are plants we do not want. They keep the plants we do want from getting enough sunlight, water, and minerals. So pull out the weeds as you thin or prune the plants in your garden.

Weeding and cultivating will keep you busy when your garden starts to grow. The boy who is hoeing is doing it correctly. He is pulling the hoe toward himself.

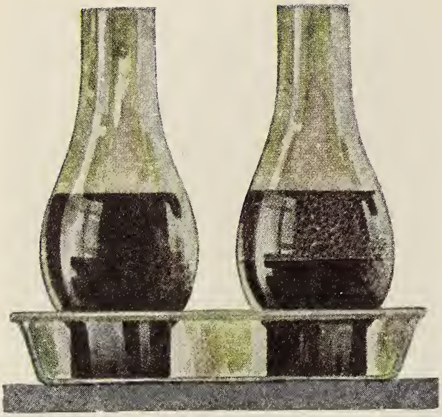
Be sure to pull out the roots of weeds like crab grass and pigweed. Also get the weeds out of your garden before they can make seeds.

You must keep the soil in your garden loose all the time the plants are growing. This is called *cultivating* the soil. You can use a hoe to cultivate your garden. Go down along each row, loosening the soil. Do not dig too deep, or you may chop off the roots of your plants. At the same time, chop out the weeds or uproot them. Getting the weeds out is one reason for cultivating a garden.

Another reason for loosening the soil is to let air get down to the roots of growing plants. Plants need oxygen from the air for the same reason that animals need it. They use the oxygen from the air to get energy from their food.

There is a third reason for cultivating the soil in your garden. All the time plants are growing, they must have water. You know that loosening the soil helps water soak in. It also helps keep water from getting out after it soaks in. You can do an experiment to see how cultivating your garden helps keep the soil from drying out.

Dig some soil from your garden and sift it through a flour sieve. Set



two lamp chimneys in a flat pan. Fill one of the chimneys half full of fine soil. Pack the soil down firmly as you put it in. Now put fine soil in the other chimney until it is one-third full. Pack the soil down firmly. Then add enough loose soil to fill the chimney half full. The soil in the two chimneys is just the same. But the soil at the top of one is much looser than the soil at the top of the other.

Pour water into the flat pan so that it can get into the soil in the chimneys. Watch the water. In which chimney does the water get to the top of the soil first? As the water gets to the top, it evaporates into the air. Watch the soil in the two chimneys for several days. In which chimney does the soil dry out first?

The loose soil in one chimney holds the water longer than the tightly packed soil in the other chimney. Cultivating loosens the soil near the top in your garden. The experiment shows you that this keeps the soil from drying out so fast.

If the weather is very dry or if the soil is very sandy, you will probably have to water your garden. When you do, give it a good soaking. Then you will not need to water more than once a week. Water your garden in the evening. Then the water can soak down to the roots before the heat of the sun makes much of the water evaporate. Keep the soil in your garden loose so that the water will soak into the ground and stay there.

Many parts of our country get enough rain and snow to supply water for gardens and farms. But the water may come at a time of the year when plants are not growing. By cultivating the soil, we can keep much of this water in the ground. Then plants can use it when they grow.

But some parts of our country do not get enough rain or snow to supply water for gardens and farms. Before plants can be raised, water must be brought to the land. Much land in the western part of our country is *irrigated* by water from mountain streams. The streams get the water from rain or snow. Dams hold back the streams and form large reservoirs. Water stored in the reservoirs can be used as it is needed. It flows many miles through ditches and pipes to the dry land. In Florida, fields are often irrigated during dry weather by water from springs.

This man is irrigating his celery field near Venice, Florida. The water is coming up through a pipe from an underground spring.

Plants must have enough water to make food and grow. But do you know what happens when plants get too much water? You can do an experiment to find out. Get two flowerpots of the same size and material. Each flowerpot should have a hole in the bottom. Cover these holes with small stones or pieces of a broken flowerpot. Then get two plants of the same kind that are about the same size. Put one plant in each flowerpot and press soil around the roots.

Set the plants side by side in a place where they can get the same amount of sunlight. Give each plant the same amount of water. After the plants are growing well, plug up the hole in one of the flowerpots. Keep on giving each plant the same amount of water every day for several weeks. Watch the plants carefully to see how they grow. Which plant grows better? Is it the one in the pot with the open hole? Does water stand in the pot with the plugged hole? Does water drain out of the other pot?

Now unplug the hole in the flowerpot. What happens to the water? If the plant is not dead, it will begin to

grow again. Watch it for several days to see what happens.

The experiment shows that too much water is just as bad for a plant as not enough water. You know that plants need oxygen to use their food. When the soil is full of water, air cannot get to the roots. The roots rot, and the plants soon die.

Sometimes water stands on the soil after a heavy rain. If it stands there for long, the growing plants will die. So we have to find a way to get rid of the water. In a garden, a little ditch will usually carry the water away. On farms, ditches are also used to drain low, wet land. But when water runs off into ditches, some of the good soil is usually carried along with it. Ditches also take up room that could be used for raising crops. Weeds often start growing in ditches and then spread to the fields.

The picture on this page shows a better way to get rid of too much water on the soil. A farmer first digs a ditch about three feet deep. Then he lays short pieces of pipe in the ditch. The pipe is made of baked clay, and it is called *tile.* The pieces of tile are laid so that they make a long tube, but a space is left between the pieces. The ditch is filled in, and the tube is covered up. Water soaks slowly down through the soil and into the tube at every space between pieces. The tube slopes a little so that the water will run off into a ditch or pond.

---

1. *Why may a row of plants in your garden have to be thinned?*
2. *Tell why you should prune tomato plants. How would you do it?*
3. *Name four things that growing plants need. How can you help the plants in your garden get them?*
4. *What are three reasons for cultivating the soil? Explain why each one is important.*
5. *Why is too much water as bad for plants as not enough water?*
6. *How do farmers keep too much water from standing on the soil?*

How are plants protected from their enemies?

IN YOUR GARDEN, a war is going on. No shots are fired, and no bombs are dropped. But it is a war just the same. And it is being fought in gardens and on farms everywhere. This is the war against the enemies of our plants. Without help, the plants would soon lose the war, for they are not very good fighters. Let us see how plants are protected from their enemies.

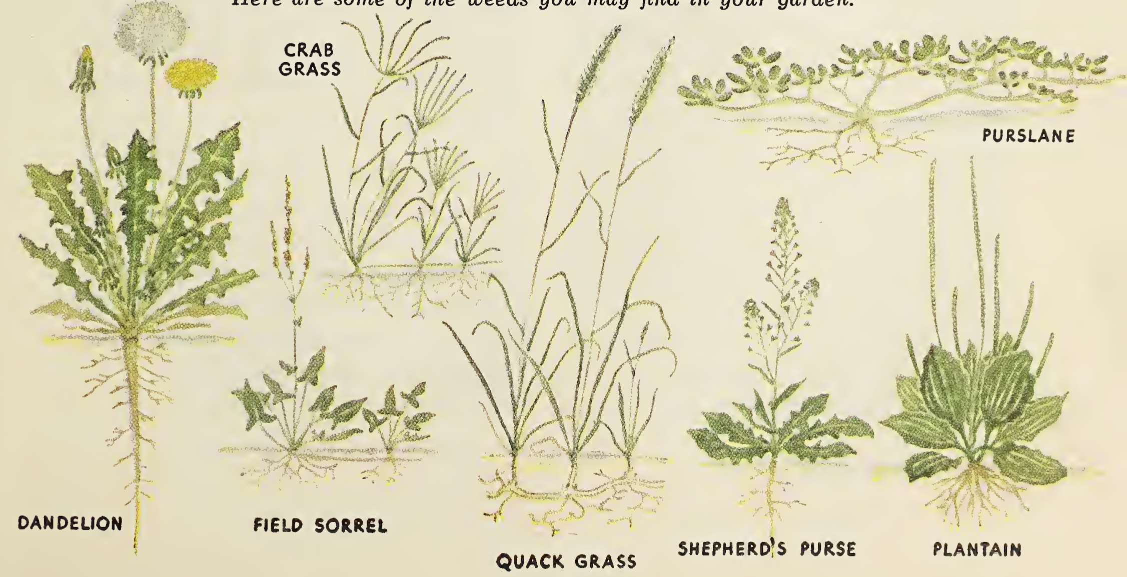
Weeds come up in your garden even though you do not plant their seeds. The seeds were in the soil all winter. When the soil became warm and moist in the spring, the seeds sprouted and the weeds began to grow. These weeds are enemies of our plants. They keep the plants from getting enough sunlight, water, and minerals.

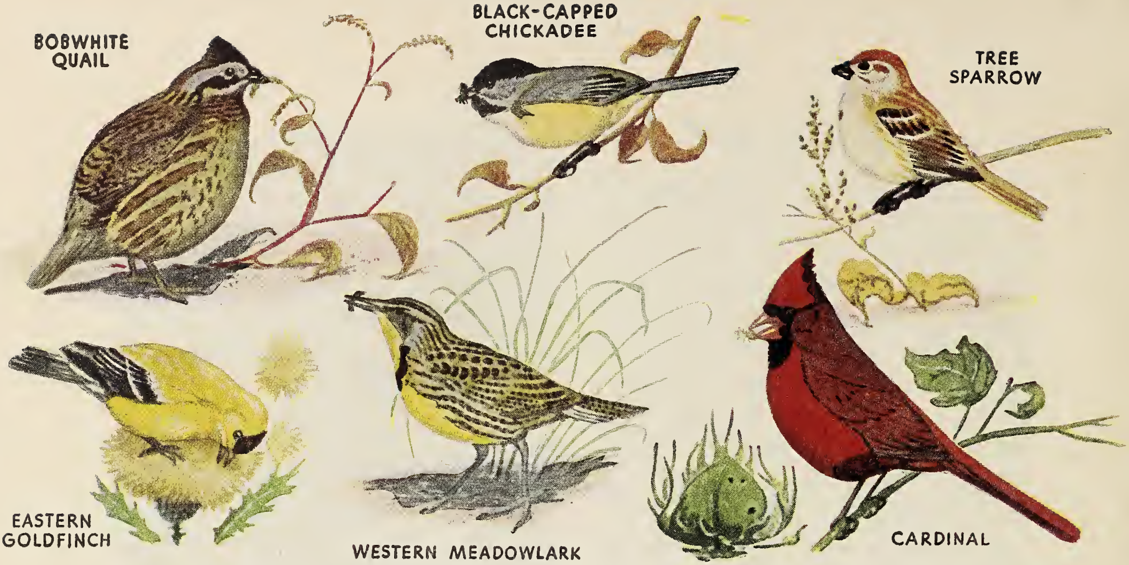
Look at some weeds, and you can see how many seeds they make. Also notice how easily the seeds are scattered. Do you see why weeds should be killed before they can make seeds? After the seeds are made, the wind may carry them for miles. No wonder weeds spread so fast and come up where we do not want them!

Crab grass is a weed that is hard to get rid of. It grows from seeds every year. You can kill crab grass by keeping it from making seeds. Dig it out by hand while it is very young. This takes time, but it is not hard to do because the roots are short. Chickweed and dandelions make seeds all summer long. Pull them up before the seeds are ripe.

The roots of some weeds stay in the ground year after year. New weeds grow from the roots. If the tops of the weeds are cut off or broken off, new shoots will soon come up. To get rid of such weeds, pull them out by the roots and then burn them.

Here are some of the weeds you may find in your garden.





Learn to recognize as many of these birds as you can. They are among our best helpers.

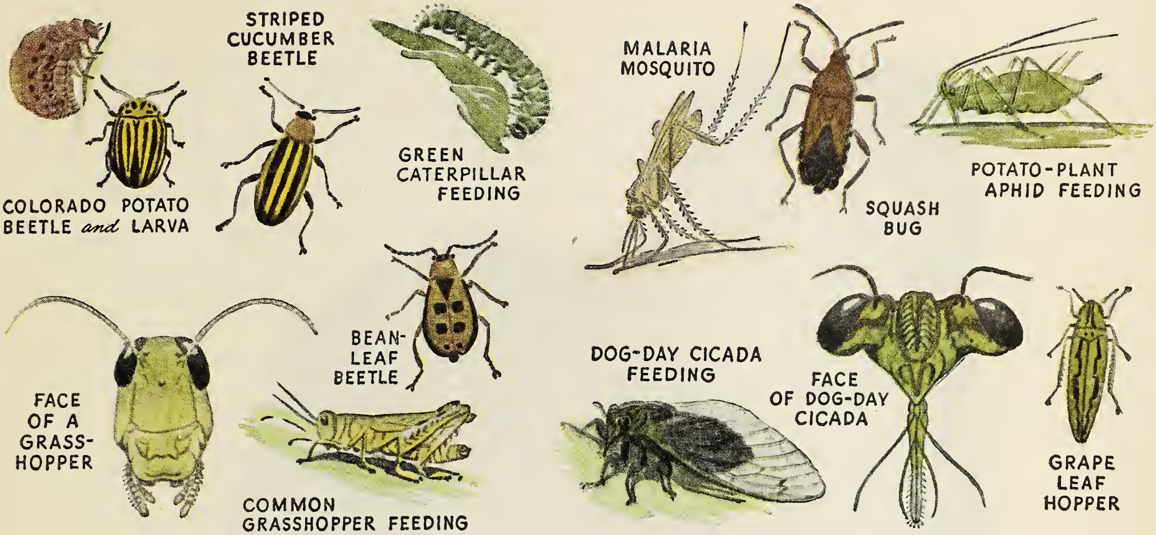
Remember the rule about not letting the weed crop win. You know that cultivating the soil helps kill weeds. But you will have to get down on your knees and pull some weeds out by hand. Farmers sometimes use strong chemicals to kill weeds in their fields.

There is another way of getting rid of weeds. We seldom think about it, but it is very important. If birds did not help protect our plants, the weed crop would surely win. Scientists have found out what birds eat by looking into the stomachs of dead birds. In the stomach of one quail, they counted 300 smartweed seeds, 500 sorrel-grass seeds, 700 mercury-weed seeds, and 1000 ragweed seeds.

Of course, these were not all the weed seeds that the quail ate in one day. Only the undigested seeds could be counted. In one day, a quail can eat many more seeds. One scientist figured out that tree sparrows in Iowa eat 1,750,000 pounds of weed seeds every year!

Birds help protect our plants in another way, too. In Unit One, you learned that insects are the most dangerous enemies of our plants. They eat the leaves, stems, roots, flowers, and fruits. Each kind of plant has at least one kind of insect enemy. Birds are the greatest protectors of plants, because they eat huge numbers of insects.

One scientist counted more than 1000 ants in the stomach of a flicker. The stomach of a nighthawk had fifty different kinds of insects in it. Every day, birds eat millions and millions of insects. If all these insects lived, they would soon destroy all the plants that we grow in our gardens and on our farms.



On the left are some chewing insects. The head of a grasshopper shows what the mouths of chewing insects are like. On the right are sucking insects. The head of the cicada shows the long tube with which sucking insects suck the sap from plants.

Birds are a great help in the war on the insect enemies of plants. But we must kill harmful insects, too. Scientists supply us with weapons for fighting the insects that eat our plants. They study the harmful insects to find out where they live, what they eat, where they lay their eggs, how they change as they grow, and many other things about them. We can use what scientists discover about insects to protect our plants.

You can study some insects to find out how they eat. Get a weed or any plant that has aphids on it. You know that aphids are also called plant lice, or ant cows. Look at one of the aphids with a magnifying glass to see how it eats. If you look closely, you will see a little tube making a hole in the leaf or stem of the plant. With this tube, an aphid sucks sap from a plant, just as you suck a drink through a straw. Insects that eat in this way are called *sucking insects.*

Many insects get their food in a different way. If you watch a grasshopper when it is eating, you will see it bite a piece out of a leaf with its jaws. They move from side to side as it chews the leaf. Insects that eat in this way are called *chewing insects.*

Scientists have found out how to kill many kinds of harmful insects by poisoning them. There are many different kinds of insect poisons. Some of them are liquids that can be sprayed on the plants. Others are powders that are dusted on plants or first mixed with water and then

Are these tent caterpillars a kind of chewing insect, or a kind of sucking insect?

sprayed on. Just what kind of poison we use depends on the way the insects we want to kill get their food.

We kill chewing insects by putting poison on the parts of plants that they eat. The insects take the poison into their bodies along with their food. So this kind of poison is called a *stomach poison.* Two chemicals often used as stomach poisons are lead arsenate and calcium arsenate. They are powders that can be dusted on plants or mixed with water and sprayed on. Use a stomach poison to kill chewing insects. Some of these are cabbage worms, tomato worms, potato beetles, Mexican bean beetles, and tent caterpillars that make tent-like webs in trees and shrubs.

We cannot use a stomach poison to kill sucking insects. They get their food inside plants where poison cannot reach it. But we can kill them by putting on the plants a kind of poison that will touch their bodies. This poison will get into the breathing holes of the insects and kill them. Because this kind of poison must touch the insects to kill them, it is known as a *contact poison.* Tobacco extract is a good contact poison.

To kill aphids, use a contact poison. Follow the directions carefully. Spray or dust the poison on the plants where the aphids are feeding. You will be surprised how quickly they are killed. Other sucking insects can be killed with contact poisons. One of these is the cucumber beetle that feeds on cucumber, squash, and melon vines. Another is the stinkbug often found on berry plants.

Not many years ago, scientists discovered a poison that kills many kinds of insects. This poison is called *DDT*. It kills both chewing and sucking insects. DDT is very good to use on the Japanese beetle and the potato beetle. It is also very good for killing flies, mosquitoes, and some other insects that are pests in the house.

Unfortunately, DDT will not kill every kind of chewing and sucking insect. It does not kill the Mexican bean beetle or the cotton boll weevil. And it does not kill all the insects that are sometimes pests in the house.

All insect poisons must be used with care. Some of them, such as lead arsenate, tobacco extract, and DDT are also poisonous to people, pets, and farm animals. Use these poisons only on parts of a plant that are not used for food. Or use them when the plants are just beginning to grow.

One of the best and safest poisons to use in killing insects is *rotenone*. It will kill both sucking insects and chewing insects, because it is a contact poison as well as a stomach poison. It is not poisonous to people, pets, or farm animals.

An insect larva called the cutworm is one of the worst enemies of young plants. It works at night, and it eats right through stems near the ground. Cutworms often kill young plants the first night after they have been transplanted. You may lose all of your tomato plants in this way. Cutworms also eat the shoots of sweet corn just after they push above the soil.

You can use a stomach poison to kill cutworms. Put some poison bait on the soil before young plants are transplanted or before the shoots come up. The poison bait is made by mixing a poison with bran and water.

Sally is spraying her zinnias with a stomach poison. How could she tell that she should use this kind of poison?

Another way to protect plants against cutworms is to put a piece of stiff paper around the stems. The paper should be about one inch above the soil and go down about two inches under the soil. This keeps the cutworms from getting to the stems.

Plants have other enemies besides weeds and insects. In Unit One you learned that tiny fungi cause potato blight, corn smut, apple rust, and wheat rust. The fungi grow on the green plants and use them for food. Then the green plants are spoiled so that we cannot use them ourselves. Scientists have found ways to protect green plants from some of these fungi. A spray or powder made from sulphur is one of the commonest chemicals used to kill fungi. Many fungi are hard to control, and they do a great deal of damage to our crops.

---

1. *Why are weeds harmful to the plants we grow? Give some ways of getting rid of weeds.*
2. *What things must scientists find out about insects before they can fight them? Why?*
3. *Give two different ways that insects get their food from plants.*
4. *Would you use a contact poison or a stomach poison to kill each of these insects?*
   Cucumber beetle　Cabbage worm　Potato beetle　Aphid
5. *Why is rotenone a good poison for killing insects on plants?*
6. *Tell how birds help protect plants from their enemies.*

QUESTIONS TO ANSWER

1. If you made a garden at home or at school, tell how this unit helped you get it ready and then take care of it.

2. What are the most important crops grown in your community or in your state?

3. How do farmers in your community or state kill insects that eat their crops?

4. If scientists did not help gardeners and farmers, how would gardening and farming be different?

5. When the Indians planted corn, they sometimes put a dead fish in the ground with the seeds. Do you think this would help the corn grow? Explain your answer.

6. Suppose that your garden had sour clay soil. What could you do to improve the soil? What could you do if the soil was too sandy?

7. Would you plant corn on the north or south side of your garden? Why?

THINGS TO DO

1. Find out how plants can be grown without soil.
2. Visit a greenhouse and learn how plants are grown there.
3. Learn the names of the weeds and insects that are the commonest enemies of the plants in your community.
4. If you can, visit an up-to-date farm or an experimental farm. Find out what crops are grown and what kinds of farm machines are used.
5. Read newspapers and magazines for more information about weed control, insect poisons, gardening, and irrigation. Cut out the articles and bring them to school.
6. Find out more about the insect poison called DDT.
7. Study a map that shows the amount of rainfall in all parts of the United States. What parts need to be irrigated? What parts have enough rainfall to grow crops?
8. Learn the names of the most helpful birds in your community.
9. Collect pictures of farm machines and find out how each machine is used.
10. Find out more about fungi that are enemies of the plants we grow in our gardens and on our farms.
11. Find out about the weed killer called 2, 4 D.

SCIENCE WORDS

Can you say the word *element?* Do you know what it means? You can easily find out. Look in the list of science words that begins on this page. The word *element* is on page 247.

Notice that each word in the list is printed two times. The second time shows you how to say the word. Some of the letters have marks over them. The mark tells how the letter sounds. Look in the list below to see how each letter sounds.

Now look at the word *backfire* near the bottom of this page. The slanting mark **ʹ** after *bak* is bigger than the slanting mark ʹ after *fīr*. So you say *bak* with more force than *fīr*.

a	hat, cap
ā	age, face
ã	care, air
ä	father, far
e	let, best
ē	equal, see
ėr	term, learn
i	it, pin
ī	ice, five
o	hot, rock
ō	open, go
ô	order, all
u	cup, butter
u̇	full, put
ü	rule, move
ū	use, music
ə	represents:
a	in about
e	in taken
i	in pencil
o	in lemon
u	in circus

ac id (asʹid), a sour material that turns blue litmus paper red.

a phid (āʹfid), a very small insect that lives by sucking the sap of plants; a plant louse.

au to mat ic stok er (ôʹtə matʹik stōkʹər), a machine to control the amount of coal supplied to a fire.

back fire (bakʹfīrʹ), a controlled fire set to stop a forest fire or grass fire by burning off the space ahead of the fire.

bac te ri a (bak tērʹi ə), very, very tiny plants that often cause diseases.

ba ke lite (bāʹkə līt), the name for a kind of plastic.

ball bear ing (bôl bãrʹing), a bearing in which parts turn on a number of loose metal balls.

bat ter y (batʹər i), a set of two or more electric cells connected to produce electric current.

bear ing (bãrʹing), a part of a machine on which another part turns or slides.

bee bread (bēʹbredʹ), a brownish, bitter substance made from pollen and honey. It is used by bees for food.

belt (belt), a band put around two wheels so that one wheel will turn the other.

ber i ber i (berʹi berʹi), a disease caused by lack of vitamin B_1. It affects the nerves and causes loss of weight.

block and tack le (blok ənd tak′əl), two pulley blocks and a rope used together to lift or pull something.

boil ing point (boil′ing point), the temperature at which a liquid boils.

car bo hy drate (kär′bō hī′drāt), a compound of carbon, hydrogen, and oxygen.

car bon tet ra chlo ride (kär′bən tet′rə-klō′rīd), a colorless, noninflammable liquid that changes to a heavy gas when heated.

cell (sel), 1. a container that holds materials for producing electric current by a chemical change. 2. the smallest part of a living thing. All animals and plants are made of cells.

cel lo phane (sel′ə fān), the name of a thin, clear plastic.

cel lu loid (sel′ū loid), the name of a hard, inflammable plastic.

char ac ter is tic (kar′ik tər is′tik), a special feature of a material that makes it different from other materials.

chem i cal change (kem′i kəl chānj), a change in a material that makes a new material with different characteristics.

chew ing in sect (chü′ing in′sekt), an insect that gets food by biting and chewing a plant with its jaws.

chlo ro phyll (klō′rə fil), a green material in leaves that is needed by a plant to make food.

cold frame (kōld frām), a glass-covered frame set in the ground. It is used to protect and warm young plants.

col o ny (kol′ə ni), a group of animals or plants living or growing together.

com bine (kəm bīn′), join together to make a compound.

com bus ti ble (kəm bus′ti bəl), able to catch fire and burn.

com pound (kom′pound), a material made of two or more different elements joined together.

com press (kəm pres′), squeeze together.

con ser va tion (kon′sər vā′shən), protection and wise use of wild life, etc.

con tact poi son (kon′takt poi′zən), a poison that kills insects when it touches their bodies.

con tract (kən trakt′), get smaller.

cul ti vate (kul′ti vāt), loosen the soil around growing plants.

curd (kėrd), the thick part of milk that separates from the watery part, or whey, when milk sours.

drone (drōn), a male bee.

e las tic (i las′tik), able to spring back to its original size or shape after being stretched or squeezed.

el e ment (el′i mənt), the simplest kind of material from which other materials are made. Scientists have discovered 96 different elements.

en rich (en rich′), make richer. Adding vitamins and minerals enriches food.

ex pand (eks pand′), get larger.

Fahr en heit (far′ən hīt or fär′ən hīt), according to the kind of thermometer that we ordinarily use for measuring temperature. Water freezes at 32 degrees Fahrenheit, and it boils at 212 degrees Fahrenheit.

fire lane (fīr lān), a wide path cut or plowed to remove materials that will burn. Fire lanes are used to prevent the spread of forest fires and grass fires.

fire proof (fīr′prüf′), that will not burn; almost impossible to burn.

fixed pul ley (fikst pu̇l′i), a pulley that is fastened to a support.

fric tion (frik′shən), rubbing of one thing against another.

ful crum (ful′krəm), the point on which a lever turns or is supported in moving a weight.

fun gus, plural **fun gi** (fung′gəs, fun′jī), a kind of plant that has no chlorophyll. It cannot make food for itself.

gear wheel (gēr′hwēl′), or gear, a wheel with teeth and notches on it. The teeth prevent slipping when one gearwheel turns another.

gen er a tor (jen′ər ā′tər), a machine for making electric current. It is run by steam, wind, water, or other power.

grav i ty (grav′i ti), the force that pulls all things toward the center of the earth.

har row (har′ō), a heavy frame with long teeth or sharp disks that break up the soil. Farmers use a harrow after plowing.

hot bed (hot′bed′), a glass-covered frame under which young plants are started. Extra heat is given off by a layer of manure under the soil.

hu mus (hū′məs), decayed materials in soil.

hur ri cane (hėr′i kān), a storm with very strong winds and usually with heavy rain. The wind in a hurricane blows from 70 to 100 miles an hour.

in clined plane (in klīnd′ plān), a simple machine made by sloping or slanting a board or other flat surface.

ir ra di ate (i rā′di āt), add vitamin D to certain foods.

ir ri gate (ir′i gāt), supply land with water by using ditches.

kin dling tem per a ture (kin′dling tem′pər ə chər), the temperature at which a combustible material will catch fire and start to burn.

lar va, plural **lar vae** (lär′və, lär′vē), the second part in the life of some insects and other animals. The larva hatches from the egg. The tadpoles of frogs, toads, and other amphibians are also called larvae.

lev er (lev′ər or lē′vər), a simple machine for lifting or moving a weight by pushing down or pulling up on a bar.

lit mus pa per (lit′məs pā′pər), a special blue paper used to test materials for acid. It turns red in an acid.

loam (lōm), rich soil in which much humus is mixed with clay and sand.

lu cite (lü′sīt), the name of a very hard, clear plastic.

ma chine (mə shēn′), anything used to make work easier.

melt ing point (melt′ing point), the temperature at which a solid changes to a liquid.

min er al (min′ər əl), an element or compound that living things need. Minerals are taken from the soil by plants and used to make food.

mold (mōld), 1. a kind of fungus. 2. a hollow form into which a liquid may be poured to harden into a certain shape.

mov a ble pul ley (müv′ə bəl pu̇l′i), a pulley that moves with the weight; not a fixed pulley.

nec tar (nek′tər), a sweet liquid found in many flowers.

ny lon (nī′lon), the name of a material made from coal, water, and air. Nylon is often made into thread or cloth and used instead of silk.

pas teur ize (pas′tər īz), heat hot enough and long enough to kill certain germs.

pen i cil lin (pen′ə sil′ən), a powerful germ-killing drug made from a certain mold plant.

phys i cal change (fiz′i kəl chānj), a change in a material that does not make a new material.

plas tic (plas′tik), a material that can be easily shaped or molded.

pol len (pol′ən), fine yellowish dust on part of a flower. It helps to make seeds.

pro tec tive foods (prə tek′tiv füdz), foods that contain vitamins which help prevent diseases and keep us healthy.

pro te in (prō′tē in or prō′tēn), a compound of carbon, oxygen, hydrogen, and nitrogen. Sometimes it also has sulphur and phosphorus. Proteins are found in foods such as meat, fish, eggs, milk, etc.

prune (prün), cut off or cut out parts from. Trees are pruned by cutting out some of the smaller branches.

pul ley (pu̇l′i), a simple machine made of a wheel with a rope running over it. The wheel is usually grooved.

pul ley block (pu̇l′i blok), several pulleys used together in a frame.

queen bee (kwēn bē), the mother bee in a hive.

ray on (rā′on), the name of a material made from wood or cotton fibers. Rayon is often made into thread or cloth.

reg is ter (rej′is tər), an opening through which warm air or cold air can get into or out of a room.

rick ets (rik′its), a disease that causes soft and poorly formed bones. It is caused by lack of vitamin D.

roll er bear ing (rōl′ər bãr′ing), a bearing in which parts turn on a number of loose metal rollers.

root hairs (rüt hãrz), tiny hairlike roots through which water and dissolved minerals come into a plant.

ro te none (rō′tə nōn), a poison used to kill both chewing insects and sucking insects.

scur vy (skėr′vi), a disease caused by lack of vitamin C.

sim ple ma chine (sim′pəl mə shēn′), a machine that has very few parts. Levers, inclined planes, pulleys, and wheels and axles are all simple machines.

so cial (sō′shəl), living in a group.

stom ach poi son (stum′ək poi′zən), a poison that kills insects when they eat it with their food.

suck er (suk′ər), a small shoot of a plant that grows from the stem or root.

suck ing in sect (suk′ing in′sekt), an insect that gets food by sucking sap from leaves and stems.

thin (thin), make less thick or not so close together. A thick row of plants is thinned by pulling out some plants to give the others more room.

tile (tīl), a tube made of baked clay and used as a pipe.

tin der (tin′dər), a material that catches fire easily.

trans plant (trans plant′), plant again in another place.

vein (vān), a part of a leaf which holds tubes that carry water.

ven ti late (ven′ti lāt), change the air in. Windows are opened to ventilate a room.

vi ta min (vī′tə min), any of certain necessary materials found in foods. Lack of vitamins causes diseases and poor health.

wa ter jack et (wô′tər or wot′ər jak′it), a water-filled space around the firebox of a furnace.

wheel and ax le (hwēl ənd ak′səl), a simple machine made of a wheel fastened to an axle so that they turn together.

whey (hwā), the watery part of milk that separates from the thick part, or curd, when milk sours or cheese is made.

work er bee (wėr′kər bē), one of the bees that do all the work in a hive.

INDEX

In the next few pages is a list of things that your book tells about. This list is called an *index*. You can use the index to help you find things in your book.

Notice that all the words beginning with *A* come first. All words that begin with *B* come next. Find the words that begin with *S*.

Suppose that you want to find out about different kinds of bees. First, look for *bees* in the index. What pages in your book tell about bees? Look at page 13 and find out what it tells you about bees. What does page 21 tell you? Does page 14 tell you about the different kinds of bees in a hive?

Do ferns grow in the sunshine or the shade? How does the sun help all green plants? Find the pages in your book that tell you.

A star after a number (like 29*) means that there is a picture on that page. What page has a picture of an earthworm? What pages have pictures of insects?

Acid, taste of, 128*-129*; soil, 226

Air, 113*; force of, 46*, 56*-58*; has energy, 47; heating and cooling of, 111-115; water vapor in, 112; to heat houses, 116*-117; needed for fire, 152, 154-155, 157-158; takes vitamins from food, 201; plants need, 206, 210-211, 211-213, 223

Airplane, 46, 47*; made of simple machines, 73

Alcohol, 135; boiling point of, 120; evaporates quickly, 121; for fuel, 164

Alligators, for leather, 36

Aluminum, 134; melted, 118, 119*

Animals, 12-13; help each other, 13-18; need plants, 19-20; help plants, 21-23; harm living things, 30-32; help us, 36-37; hair of, 37; conservation of, 40-41*

Ants, 15-17; colony, 16*; and aphids, 17*

Aphids, 17*

Apple, spoiled, 28*, 31*; for food, 33

Apricots, dried, 144*

Automobile, uses force, 46; has energy, 47; springs of, 50*; run by explosions, 62*; and friction, 94-95; uses alcohol, 120

Axe, 71, 72, 80; safety with, 97, 99

Axle, wheel and, 88*-90*; in bicycle, 91*

Backfire, 169-170

Bacteria, harmful to living things, 28; cause chemical change in food, 145

Bakelite, 141

Baking, 142; soda, 129, 135; powder, 145

Basic seven, 194*, 197

Battery, 66

Bearings, 95-96

Bears, conservation of, 40, 42*

Beavers, 18; conservation of, 42*

Bees, 13*-15; beebread, 14; kinds of, 14*; and honeycomb, 15*; spread pollen, 21*, 243

Beets, for food, 33; growing, 206*, 233*
Belt, around wheels, 91*, 96, 98*
Beriberi, 188-189*
Bicycle, 72-73, 91*, 95, 96
Birds, 17, 18; need plants, 20*; food for, 22, 240*-241; conservation of, 41*
Block and tackle, 70*, 86*, 100*
Blood, made by food, 185; iron for, 187; needs water, 193; carries food, 214
Body, muscles in, 48-49; chemical change in, 132; food for, 179
Boiler, in steam engine, 60
Boiling point, 120
Boll weevil, 32*
Bones, growth of, 179; calcium phosphate in, 186; vitamin D for, 191
Boron, for plant growth, 227
Brake, uses friction, 96-97
Brass, is a mixture, 119
Bronze, is a mixture, 119
Buds, sap goes to, 214-215
Buffalo, 40

Cabbage worms, 31
Cake, baking of, 142; gas in, 146*
Calcium, in body, 139, 186-187; in milk, 186; in minerals, 208; plants need, 227
Camels, help us, 36
Candy, 183
Carbohydrates, 182-185, 183*, 193; in milk, 195; made by plants, 211, 214
Carbon, 134; with copper and oxygen, 138; in smoke, 158*-160, 160-162; in fats and carbohydrates, 184, 213; in protein, 185
Carbon dioxide, 135; in soda, 126; in sugar, 135; formed in burning, 159-160; fire extinguisher, 172*-173; used by plants, 212-213
Carbon tetrachloride, fire extinguisher, 171*
Carrots, for food, 33, 190; roots of, 206
Caterpillar, tent, 242*
Cats, help us, 36
Cell, electric, 64*-65*, 66; of leaf, 213*
Cellophane, 141
Celluloid, 141
Cereal, bread, 180, 184, 191; for heat energy, 181, 182, 196; starch in, 184; wheat, 190-191; vitamin B_1 in, 191, 196
Characteristics, of materials, 126-129, 130-133
Cheese, fat in, 183; protein in, 185; phosphorus in, 187; vitamin B_1 in, 191; from milk, 195
Chemical change, 131-133, 136-138, 139*; how we use, 140-142; harmful, 143-145; in burning, 156-160; in leaves, 212-213
Chickens, food for, 32; as food, 36
Chlorine, to make salt, 138*
Chlorophyll, 210-211, 212-213*; magnesium for, 227
Clay, in soil, 223*-224, 226
Coal, for fuel, 61, 150; chemical change in, 132; is combustible, 151; conservation of, 161-162
Cold frame, 231
Combustible materials, 151, 155, 166*
Compounds, 135-139; that are useful, 140-142; that are harmful, 143-145
Compress, 128
Concrete, road, 105-106*; how to make, 140
Condense, 122
Conservation, 38-41
Contract, metals, 105; liquids, 108-109; gases, 111-113
Cooling, changes materials, 103-122
Copper, 134; wire, 103; with carbon and oxygen, 137-138; plants need, 227
Corn, smut, 28*; needs water, 29*; insects eat, 30*; borer, 31*; for food, 33; starch in, 184; roots of, 207*; takes minerals from soil, 227*, 228
Cows, poisoned by snakeroot, 27; food for, 32; for food and clothing, 36
Cranes, use pulley blocks, 70*, 86
Crows, help each other, 18
Cultivating, 235*-236
Current, electric, 53-54, 64-66, 67-68; in water, 109
Cutworms, 31

Dam, 47*, 55*
DDT, 243
Decay, and fungi, 24; aids new growth, 26
Deer, harm forests, 11-12*; conservation of, 40-41*
Derrick, 86
Diesel engine, 46, 63*
Disease, foods help prevent, 179
Dogs, help plants, 23; help us, 36*, 49*
Doorknob, is wheel and axle, 88-89*
Drones, 14*
Ducks, nest, 19*; conservation of, 40

Earthworm fertilizes soil, 22*-23
Egg, fat in, 183; protein in, 185, 196; phosphorus in, 187; iron in, 187; vitamin D in, 192
Eggs, clam, 11; bee, 14-15; ant, 16; aphid, 17; woodpecker, 20; insect, 30-32
Egg beater, 72, 89*, 90, 92
Elastic, meaning of, 128
Electric, motor, 46, 57*, 64*, 65*; current, 54-55, 64*-66, 65*, 67, 164
Elements, 125, 133-135, 134*; combined, 135-139, 140
Elevators, use pulleys, 86
Energy, 46*-48, 47*, 93; from food, 48-49, 93, 179, 181-185; of steam, 61*; heat, 61, 164; in gasoline, 62; of electric current, 64-66, 93; forms of can be changed, 67*-68; friction and, 93-94; from sun, 216
Engine, 163; Diesel, 46, 63*; gasoline, 46, 62*; steam, 59*-61; toy electric, 64*; kinds of run by generator, 66
Evaporate, 120-121, 122
Expand, metals, 104-105; liquids, 108-109; gases, 111-113
Explosions, 61-62

Fahrenheit, 118
Fans, 57*, 66*, 67
Fat, 182*-185, 193; in foods, 183; in milk, 195; made by plants, 211, 214, 218
Ferns, 25
Fertilizer, 226-228, 227*
Fire, forest, 39, 148*; tower, 39*; is a chemical change, 132*, 154-160; how we control, 149-173; how to make, 149-153, 151*, 152*; oil, 162*; to prevent, 164-167; how to put out, 165*, 168-173; Safety Rules for, 167
Fire boxes, 168*
Fire extinguisher, 171*, 172*
Fire lane, 169*
Fish, 11; as food, 36; protein in, 185; iodine in, 188; vitamin D in, 192
Fixed pulley, 83*-84, 86
Flicker, 20*
Flint, to start fire, 153
Flood, damage of, 53*
Flowers, and bees, 14, 21*-22; conservation of, 40*; sap goes to, 214-215; bulbs store food, 216; in garden plan, 224*
Food, for deer, 12*; for bees, 14; for ants, 16-17; animals use plants for 19; for fungi, 24*-25; for insects, 30*-32; plants we use for, 33; supplies energy, 48-49; changes in body, 133; spoiled, 145; why you need, 178-202; vitamins in, 188-192; Basic Seven, 194*; habits, 194-199, 202*; cooking, 199-202, 200*, 201*; green plants make, 205-218
Force, 45-48, 49, 93; of gravity, 51-52, 73, 76; of water, 53-55; of air, 56-58; of an explosion, 61-62; of lever, 73-77; changed by pulley, 82-87; of wheel and axle, 88-90; wasted by friction, 93-97
Forest, 11-12; conservation of, 39
Friction, 93-97; to start fire, 152*-153
Fruit, 184; berries, 183; bananas, 183; grapes, 183; apples, 183, 193; oranges, 183, 191, 196; prunes, 187; lemons, 188, 191; limes, 188, 191; grapefruits, 191, 196; water in, 193*
Fuel, 156-160; has energy, 61, 62-63, 93; kindling, 151*; to conserve, 160-164
Fulcrum, 74, 75*
Fungus, 24*-25; harms living things, 27-28, 244; has no chlorophyll, 210; gets food, 216-218

Furnace, 150*, 163; hot-water, 110*-111; hot-air, 116*-117

Garden, how to plan, 221, 222*-224*; preparing soil for, 225*-228, 226*; planting, 229*-232*, 230*; caring for plants in, 233*-238*, 234*, 235*, 237*, 238*; protecting plants in, 239-244, 243*
Gas, liquid changed to, 59-61*, 120-121; changed by heating and cooling, 111-115; in cake, 146*; stove, 155*; for fuel, 164
Gasoline, engine, 46, 62*-63; to start fire, 171, 174*
Gearwheel, 91-92*; safety with, 98*, 99
Geese, conservation of, 40
Generator, 66, 68*
Gentian, blue, 40*
Glass, for windows, 127; making of, 140*
Gold, 134
Gravity, 51-52, 73, 75-76; and air current, 57, 115, 154; and air, 113; causes current in water, 109
Grease, decreases friction, 94-96; prevents rust, 144
Greenhouse, 230-231
Grouse, 41*

Hammer, 72; safety with, 97-98
Harrow, 225-226*
Heat, 60; from friction, 94-95; can change materials, 103-122, 126; from burning, 156; conserving, 163*; of body, 181-185; takes vitamins from food, 201
Heath hens, 40
Hemp, 33*
Hoe, 225, 235*
Honey, 14; comb, 15*
Hotbed, 231*
Hot-water, heater, 109*; furnace, 110*-111
Humus, in soil, 223-224, 226; from manure, 228
Hurricane, 56*
Hydrogen, in sugar, 135; in water, 136; from candle, 159-160; in fats and carbohydrates, 184; in protein, 185

Ice, decreases friction, 93, 96; melting point of, 118*
Inclined planes, 78*-81, 80*; friction in, 93, 96
Indian pipes, 218*
Insects, 22, 30-32, 39-40, 240-244, 241*, 242*
Iodine, a mineral, 188
Iron, 134-135; magnet, 64; heating and cooling of, 103-105, 118; rust, 131, 144; with sulphur, 136*-137*; with oxygen, 137; in body, 139, 187-188; in food, 187; in minerals, 208; plants need, 227
Irrigate, 236-238, 237*

Jack-in-the-pulpit, 25*
Jackscrew, 81*, 101*

Kerosene lamp, 155*
Kindling temperature, 151, 155
Knife, 72, 80; safety with, 97*

Lady's slipper, 40*
Larvae, on caterpillar, 30*, 31*-32
Lead, melting point of, 118*, 130; is an element, 134; in paint, 138
Leaves, eaten by insects, 31*; in autumn, 131; veins in, 209-210*; breathing pores in, 210*-211; make food, 211-214, 214-216; cells of, 213*
Leopard, snow, 10*
Levers, 73-77*, 75*, 76*, 89; have friction, 93; safety with, 99
Lime, for acid soil, 226
Liquids, gasoline, 62; heating and cooling of, 107*-109; solids changed to, 118-119; changed to gases, 120-121
Litmus paper, 128*-129
Living things, need each other, 11-43
Loam, 223*-224, 226
Locomotive, 59*, 60*, 68, 72-73
Lucite, 141

Machines, run by water, 53; use steam, 60; gasoline engines are, 62; run by electricity, 64-65; make work easier, 71-99; safety with, 99; farm, 225-226*

Magnesium, for chlorophyll, 227
Magnet, 64*; in motor, 65*
Manganese, for plant growth, 227
Manure, fertilizer, 228; for hotbed, 231*
Maple, tree, 211, 214*
Matches, safety with, 153, 165
Materials, 126-129*, 127*; safety in handling, 129; characteristics of, 130-133; made of elements, 133-135; made of compounds, 135-139; new, 140-142; changes in, 143-145; combustible, 151
Meat, 180; fat in, 183; protein in, 185; iron in, 187; liver, 187, 191, 192; loses value in cooking, 200-201
Meat grinder, 90
Melting point, of solids, 118*
Mercury, is an element, 134
Metal, molten, 102*, 119*; heat changes size of, 103-105*, 104*
Mexican bear beetle, 31*
Microscope, 9*
Milk, 180; protein in, 185, 186, 195*; fat and sugar in, 186; minerals in, 187, 196*; vitamin B_1 in, 191; water in, 193; contents of, 195*; pasteurized, 201
Mill, 53-54*
Minerals, 186-188, 187*, 193; in milk, 195; lost in cooking, 199-201; in soil, 205, 208, 210-211, 213; in fertilizer, 226-228
Mistletoe, 24*, 25, 27
Mold, 28; food for, 213, 217*-218, 217*
Movable pulley, 85-87
Muscles, 46, 72, 75; energy in, 46-48, 48-49
Mushrooms, 24; harmful, 28; cannot make food, 213, 216-218

Nectar, for honey, 14, 21*
Nickel, 134
Nitrogen, 134; in protein, 185; helps plants, 227, 228; in manure, 228
Nylon, 142

Oil, as a fuel, 63, 161, 164; decreases friction, 94*-96; prevents rust, 144; conserving, 162*
Orange, for food, 33
Oriole, nest, 20
Owls, help us, 36
Oxen, help us, 36
Oxygen, 134; in sugar, 135; in water, 136; makes rust, 137; with copper, 138; to make paint, 138; for burning, 157-158; in body, 181; in fats and carbohydrates, 184; in protein, 185

Paint, 138, 143*
Paper, how to make, 141*; burning of, 151
Parachute, 52*
Paraffin, melting of, 118*, 130*; burning of, 158*-160
Peat moss, for soil, 226
Penicillin, from mold, 34
Perspiration, 193
Pheasants, conservation of, 40
Phosphorus, in body, 139; in milk, 186, 195; in liver, 187; in minerals, 208; helps plants, 227, 228
Physical change, 130
Pigeons, passenger, 40
Pigs, food for, 32; as food, 36
Pine, trees hold soil, 35*
Pine beetle, 32*
Pipes, 57-58, 110-111
Pitcher plant, 27*
Plants, 12-13; help animals, 19*-20; are helped by animals, 21-23; help each other, 24-26; harm living things, 26-29; help us, 33-35; for medicine, 34; hold soil, 34-35*; make food, 205-218, 209-214; roots of, 206-208; store food, 214-216; without chlorophyll, 216-218; transplanting, 232*; care of, 233-238
Plastics, 141-142*
Plow, 80, 225-226*
Plums, spoiled by fungi, 27-28*
Poison, for insects, 242-243*
Poison ivy, 26*-27
Pollen, for beebread, 14; carried by bees, 21*
Pores, in leaf, 210*-211

Post-hole digger, 100*
Potassium, for plants, 227, 228
Potato, 33, 180; blight, 28; starch in, 184; iron in, 188; water in, 193*; takes minerals from soil, 227
Pounds, measure of weight, 52, 75; of force, 79, 85
Prairie dogs, help each other, 18*
Protein, 185-186*; made by plants, 211, 214, 218
Pruning, trees, 233-234; tomatoes, 234*
Puffballs, 24; make no food, 213, 216-218
Pulleys, 82*-87*; fixed, 83*, 84*; movable, 85*; in block, 86*; have friction, 93; safety with, 98

Queen, bee, 14*-15; ant, 16

Rabbits, 17; harm plants, 30
Radiators, 110*
Rain, washes away soil, 34*
Rake, 225*
Rats, experiment with, 180*-198*
Rayon, 142
Rice, 188-189; vitamin B_1 in, 190
Rickets, 191-192*
Road, is inclined plane, 78*, 80; making concrete, 105-106*
Robins, 17
Roller, 95*; bearing, 96
Roller skates, 94*, 95*, 96
Roots, 206*-209; hairs of, 207-208*; sap goes to, 214-215*; store food, 215
Rotenone, 243
Rubber, trees, 33; bands, 127-128
Rust, 131*, 137; prevention of, 143*-144

Safety, with machines, 97-99; in handling materials, 129; in using matches, 153; for preventing fires, 167
Salt, 120, 121*; in water, 130; sodium and chlorine in, 138*; iodized, 188
Sand, to make glass, 140*; in soil, 223*-224, 226
Sap, eaten by insects, 32; of maple trees, 214*; in plants, 214
Saw, 71, 72; safety with, 97-99
Scales, 52
Scissors, 72
Screws, 81*
Scurvy, 188; lemon or lime for, 188, 191
Seeds, and pollen, 21; spread by animals, 23; sap goes to, 214; food stored in, 216; planting, 224, 226, 229*-231, 230*
Seesaw, 73-74*, 75*; safety with, 99
Sewing machine, 73; needs oil, 95
Sheep, food for, 32, 176*; we use, 36*
Silver, 134
Skin, 179
Skunks, help us, 36
Smoke, carried by air, 113-115; from burning, 156, 158*, 160-162, 161*
Snakes, help us, 36
Sodium, for salt, 138*
Soil, earthworms fertilize, 22*-23; held by plants, 34*-35*; carried by moving air, 56; minerals in, 206-208; types of, 223*-224; preparing for planting, 225-228, 226*; holds water, 236*, 237*
Solids, heating and cooling of, 103-106; changed to liquids, 118-119
Soybeans, protein in, 185
Spade, 225
Spokes, of wheel, 89-90
Spores, of bread mold, 217*
Springs, 50*; balance, 79, 83, 85*, 86, 88
Starch, 183-184*; made by plants, 214, 218
Steam, 59*-61*; engine, 46, 59*-61; a gas, 59; is water vapor, 122*
Steering wheel, 89, 90*
Stoker, automatic, 162
Sugar, 130-131, 135-136; a carbohydrate, 183; in fruit, 183; in milk, 195; beets, 206*, 211; made in green leaves, 211-214, 218; cane, 211
Sugar tongs, 77*
Sulphur, 134; with iron, 136*-137*; in protein, 185; in minerals, 208; plants need, 227

Sun, plants protected from, 25*; plants reach for, 25*-26, 28; causes change in colors, 145; vitamin D from, 192; helps green plants, 212*-213, 216, 223

Tack puller, 76, 77*
Tar, in concrete road, 106*
Taste, 126, 128
Teeth, 80, 179, 186; of gearwheel, 91-92*
Temperature, 118; kindling, 151
Thermometer, 107-108, 120
Threshing machine, 58*
Tin, will not rust, 144; cans, 131*
Tires, cause friction, 96
Tomato worm, 30*
Tomato plants, 227*, 232*, 234*
Tools, 71; for gardening, 225*-226*
Trains, 46, 63*
Transplanting, 232*
Trees, help hold soil, 34-35*; for lumber, 38*-39; parts of carry water, 209*; store food, 215
Trillium, 40*
Tungsten, 134
Turbine, steam, 61*
Turpentine, 33*

Vegetables, 180, 184, 215; corn, 184; beans, 184, 185; peas, 185; protein in, 185; calcium and phosphorus in, 187*, 196*; tomato, 188, 190, 191, 196; carrots, 190; spinach, 190, 191; vitamin B_1 in, 191; contain water, 193*; lose value in cooking, 199-200*, 201*; garden plan, 224*
Veins, of leaf, 209-210*, 211, 213*
Ventilate, rooms, 117*
Venus's flytrap, 27*
Vine, 25*
Vinegar, is acid, 128*
Vitamins, 188-192, 190*, 191*, 193; A, 190; B_1, 191; C, 191, 196; D, 191, 192*; in milk, 196; lost in cooking, 199-201*
Volcanos, 118

Washing machine, 95; safety with, 97
Water, 136, 139*; force of, 46, 53*-55*, 66*-67*; has energy, 47; expands and contracts, 108; vapor, 120, 122*; characteristics of, 130; from candle, 159-160; to put out fire, 170*; in body, 193; in food, 193*; takes vitamins from food, 200*-201*; used by plants, 207-208, 209*, 210-211, 211-213; held by soil, 224, 236*; for irrigation, 236-237*; drainage of, 238*
Waterfall, 44*, 55
Water jacket, in furnace, 110*
Water wheel, force of, 46, 53-55*; has energy, 47; how to make a, 54*; runs a generator, 65
Wax, bees use, 14; decreases friction, 93; changes when heated, 130*
Weasel, 30*
Wedges, 71, 72, 80*
Weeds, 28; in garden, 234-235*, 239*-240
Weight, 51, 75, 79, 85; of water, 109; air has, 113; and growth, 178*, 180*, 198*
Wheat, rust, 28; for food, 33
Wheel, run by steam, 61*; run by explosion, 62; in pulleys, 82-87; and axle, 88*-90*; turns other wheels, 91*-92*, 96; has friction, 93; reduces friction, 95-96; safety with, 98*
White snakeroot, 27
Wind, moves soil, 35, 56; has energy, 47; pushes boats, 56-57; turns windmill, 58*; runs generator, 68*
Windlass, 90*
Windmill, 46, 58*, 68*, 72
Wood, eaten by beetle, 32*; for paper, 33, 141*; decaying of, 131; burning of, 132, 149, 151*, 164
Woodpecker, 20, 37*
Work, made easier, 71-99, 72*
Worker, bees, 14*; ants, 16

Zinc, 134*; to make paint, 138; for galvanized iron, 144; plants need, 227

9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 55 54 53 52 51 50

Q 163 B37 GR-5 TCH-ED-
BEAUCHAMP WILBUR LEE 1891-
CURRICULUM FOUNDATION SERIES

39415582 CURR HIST

000017967605

DATE DUE SLIP

EDUC MR 21 '77
EDUC MR [illegible] '77
EDUC [illegible] '77

Returned SEP 19 '77

F255

EDUCATION LIBRARY